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EDITOR

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PLATE I.

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COMET 1910*a*

Photographed at the Dominion Astronomical Observatory by R. M. Motherwell.
January 25d 11h 15m G.M.T. Exposure 10 minutes.

PLATE II.

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COMET 1910*a*

Photographed at the Dominion Astronomical Observatory by R. M. Motherwell.
January 28d 11h 22m G.M.T. Exposure 25 minutes.

PLATE III.

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COMET 1910*a*

Photographed at the Dominion Astronomical Observatory by R. M. Motherwell.
January 31d 11h 19m G.M.T. Exposure 25 minutes.

PLATE IV.

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HALLEY'S COMET, February 10, 1910.
Photographed at the Dominion Astronomical Observatory, Ottawa,
By R. M. Motherwell.
Exposure 1h 40m.

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# RECENT DISCUSSION IN ASTRONOMY AND ASTROPHYSICS

BY W. BALFOUR MUSSON

(ANNUAL ADDRESS OF THE RETIRING PRESIDENT)

THE great astronomical event of 1909 was, undoubtedly, the re-discovery of

HALLEY'S COMET

which, after an absence from view of seventy-three years and four months, was again sighted on the 11th September. As is well known to all students of astronomy, this comet is possessed of an unique interest in consequence of its being the first of these celestial visitors whose periodicity was determined.

In the first century of the Christian era the Roman Seneca made a prophecy that: "Some day there will arise a man who will demonstrate in what region of the heavens the comets take their way; why they journey so far apart from the planets; what their size and nature." The world awaited that man for 1600 years, but the faith of the old Roman was eventually justified.

In 1665 an attempt had been made to predict the movement of the comet of the preceding year, but the knowledge of such bodies was at that time extremely vague and it was reserved for Halley, nearly half a century later, to demonstrate this great

triumph of the Newtonian law ; the fulfilment of his prediction, however, not coming until seventeen years after his death.

In August, 1684, Edmund Halley made a memorable journey to Cambridge for the purpose of propounding a question to the illustrious Newton : the question was "whether a body moving toward the sun under the influence of an attractive force, varying inversely as the square of the distance, would describe an ellipse with the sun in focus." Newton's reply was that he had already proved the truth of this proposition, although with his well known carelessness, or modesty, he had mislaid his manuscript.

Newton was not concerned overmuch with questions of "priority," and upon one occasion he wrote to Flamsteed : "I no not love to be printed upon every occasion, much less to be teased by foreigners about mathematical things, or to be thought by our own people to be trifling away my time about them, when I should be about the King's business."

Halley saw to it, however, that the proof was resurrected, and it may be said in passing that to him was largely due the production of the immortal "Principia," which he published at his own expense.

For some twenty years afterwards Halley was engaged in other and important scientific work, but he had not forgotten the great truth imparted to him, and upon his appointment to the Savilian chair of geometry at Oxford in 1703 he returned to the subject, and with extraordinary labor calculated the orbits of twenty-four comets. Among these orbits were three which so closely resembled one another that Halley ventured his now famous prediction that the comets of 1531, 1607 and 1682 were identical, and that the next apparition would occur at the end of 1758, or the beginning of 1759.

As the time drew near great interest was aroused among astronomers, and the mathematician Clairaut worked out a new and careful investigation of the comet's orbit. He announced that perihelion would probably be reached in April, 1759, although with far reaching intelligence he qualified his statement

by saying that owing to the possible existence of unknown planets, or other disturbing causes, the date fixed might be advanced or retarded by a month. It should not be forgotten that when Clairaut made his calculation neither Uranus nor Neptune had been discovered. The comet was picked up on the 25th December, 1758, by George Palitzch, a farmer and amateur astronomer, living near Dresden, and Halley's fame was for all time established. Perihelion passage occurred on the night of 12th March,—within the limit of error allowed by Clairaut.

Before the next return in 1835 Pontécoulant and Damoiseau in France, and Lehmann and Rosenberger in Germany, made fresh computations of the comet's elements, and, armed with improved mathematical methods, and a more accurate knowledge of the solar system, attained much greater accuracy than had been possible three quarters of a century earlier. Pontécoulant fixed the date of perihelion passage for the 12th November and Rosenberger for the 11th. Diligent watch was kept during the summer of 1835, and on the 6th of August the comet was seen by Father Dumouchel at Rome. Perihelion was reached on 16th November, just four days later than the date foretold by the renowned French mathematician. The comet passed into the southern hemisphere in January 1836, and was observed by Sir John Herschel until the following May when it finally disappeared on its long journey into space of 3,370,000,000 miles.

Since that time it had been seen by no human eye until in September last it was detected by the photographic plate set to catch it.

With the invention of great modern telescopes, and the introduction of astronomical photography, it was confidently expected that upon its visit to the sun in 1910 the comet would be picked up while yet hundreds of millions of miles distant from the vicinity of the earth, and search was begun early in last year. True to anticipation its discovery was announced, as above stated, on 11th September by Professor Max Wolf, at Heidelberg. Plates taken at Greenwich Observatory, when afterwards examined, showed it to have been recorded two days earlier, and the Astronomer

Royal announced at the meeting of 10th December of the Royal Astronomical Society that an examination of negatives made with the Reynolds reflector at Helwan Observatory, Cairo, revealed an image of the comet on a plate exposed on 24th August. It was photographed at the Lick Observatory on the 12th September, and observed visually at the Yerkes by Burnham on the 15th, and by Barnard on the 17th, being then of the 15·5 mag., and 12″ in diameter.

As early as 1864 Pontécoulant had announced that it would turn the sun on the 24th May, 1910. Messrs. Cowell and Crommelin of the Greenwich Observatory, however, went carefully over the ground, and Mr. Crommelin corrected the date to 16th April. Revised calculations, based upon observation, since the comet's discovery, indicate the true date as 18th April. Great interest will attach to the determination of the time of actual passage ; when this event occurs the comet will be travelling at the rate of 1800 miles per minute.

The history of this famous comet has been traced back with certainty to the year 87 B.C., and with a fair degree of probability to 240 B.C. It will be seen, therefore, that Halley's comet is a very old visitor to the earth, and is worthy of all the attention that may be bestowed upon it when, in the early spring, it becomes a good object for observation. Arrangements are being made to follow it photographically during the entire period of its visibility around the earth. A station will be established at some point in the Pacific Ocean to enable this programme to be completed, and it is confidently expected that fresh and valuable information will be obtained regarding the nature of these still somewhat mysterious bodies.

In its palmy days Halley's comet was a magnificent sight, one account describing it as covering 100 degrees in the heavens, and although it has lost much of its glory during the course of its strenuous life it should still show something of its ancient splendor. In 1835 it covered about 20 degrees of arc.

A question of never failing popular interest is, what are the chances of a comet striking the earth? It may tend to re-

assure any who may have misgivings on this point to say that Babinet considered a collision likely to occur once in about 15,000,000 years. Prof. W. H. Pickering gives some interesting figures in a pamphlet recently published. Taking the average diameter of the heads of telescopic comets to be 70,000 miles he calculates that the core of one comet in 100,000,000 will probably strike the earth. That would mean that, upon the basis of the number of these objects that have been discovered in the last half century, a collision with the nucleus of a visible comet should be expected once in 400,000,000 years, and with some portion of the head once in 4,000,000 years.

Those concerned as to the probable effect of a catastrophe of this nature, or in the existence of evidence of such having occurred in the past history of the earth, will find some interesting material in the monograph referred to.

## THE SUN

An interesting contribution to the literature of solar research appeared during the early part of last year in the publication of Dr. Geo. E. Hale's Hamilton Lecture at Washington.

The sun presents two claims to the attention of astrophysicists which places it in the forefront of objects of scientific interest. First: its importance as a typical representative of the stellar hosts, and second: its influence upon terrestrial conditions. If we know the physical forces operating in the sun we hold a key to the physical history of the Universe, and, as Hale truly remarks, when it is considered that a fall of 0·6 per cent. in the temperature of the sun would probably bring about an ice age upon the earth we can scarcely afford to ignore even minute changes in the solar constant.

In this field of investigation work is being actively prosecuted at the astrophysical observatory of the Smithsonian Institution, where Mr. Abbot is endeavoring, with much perseverance, to surmount the great difficulties peculiar to this research.

It is generally admitted that the average temperature of the earth is subject to a periodic fluctuation, and it is of primary

importance to determine whether this variation is extra-terrestrial, or whether it is due to the absorption of the earth's atmosphere. Mr. Abbot inclines to the former explanation, and, as he has been able to demonstrate the slight changes in solar heat caused by the earth's varying distance from the sun, we may hope that the more difficult problem of the solar constant will also yield to his attack.

An important advance in the history of solar physics was marked by the formation of the International Solar Union. At the Oxford meeting of the Union in 1905 coöperation in the study of sunspots, spectroheilograph work, and measurements of solar radiation, as well as the adoption of a new system of standard wave lengths, was agreed upon. The latter will be expressed in terms of the wave length of the cadmium lines, and it is expected that new tables of the wave lengths of solar, metallic and gaseous spectra will soon be available. In accordance with the programme prepared the sun is being daily photographed in monochromatic light in England, France, Germany, Spain, the United States and Sicily. The next meeting of the Union will be held this year at Mount Wilson, and action has been taken by the Council of this Society which it is hoped will result in the Society being there represented.

A paper on "The Constitution of the Sun" appeared in the *Astrophysical Journal* for January last. The theory of its author, Dr. Schultz, is based upon the assumption that the sun consists of a solid or liquid nucleus, in a state of incandescence, surrounded by an atmosphere at a lower temperature, the most reliable estimate of the mean temperature of the solar radiating layers placing it at about 5400° C. Schultz believes the variation in temperature at different levels to be much less than generally conceded, although he allows that the upper surface may be cooler, and the nucleus hotter than the mean. His conclusion, based upon numerous facts of experience, is that it is erroneous to regard the sun as a completely gaseous body. In reply to the objection that the gaseous state only could furnish constancy of radiation, and that a liquid star would soon become covered by a non-lumin-

ous crust, he argues that this is true only under certain conditions; for instance, if a star to a depth of, say half its radius, be of uniform density extensive convection currents may be assumed and it would act as a fairly constant radiator. Should the outer layer of least density, however, be relatively thin this layer would cool and a crust would form. This latter condition he points out might explain the fact that in some binaries one component is found to be less brilliant than its companion, while in the event of the outer crust being very thin it may at times be broken up, thus accounting for the light changes in a certain well known class of variables.

It is, of course, to spectroscopy that we must mainly look for fresh light upon such questions, and great results may be expected from the new, and projected, tower telescopes of the Mount Wilson Observatory. The 60-foot instrument has given such satisfactory results that arrangements are being made for the erection of a second tower in which the objective will have a focal length of 150 feet, and the spectroscope will be some 75 feet below the surface of the earth, the instrument giving an image of the sun about 16 inches in diameter. The advantages of this new and peculiar form of telescope are, the reduction of the atmospheric disturbances affecting the objective and mirrors, and the greater constancy of temperature secured by the depression of the spectroscope.

An interesting controversy has arisen in connection with the question of the temperature of

SUNSPOTS

The correctness of the opinion that the existence of compounds in spots is evidence of a temperature below that of the surrounding photosphere has been questioned by Professor Whittaker who contends that this phenomenon might be equally well explained by an increase of pressure. Mr. Evershed has made measurements of the lines in spot spectra for the purpose of determining whether any displacements could be detected which might reasonably be attributed to this cause, but found no evidence of a

pressure sufficient to explain the observed facts. The observations of *Mira* made by Father Cortie likewise seem to confirm the view that the compounds in question are due to reduced temperature. When *Mira* was brightest in 1906 the titanium oxide bands were weak, and the bright hydrogen lines more intense than during the fainter maximum of 1897. Professor Fowler also throws the weight of his opinion in favor of the low-temperature theory.

The year 1909 is a notable one in the history of

ASTROPHYSICS

since it marks the completion of the first half century of the new astronomy. It is strange, when looking over the past history of this subject, to note how many investigators held the secret of the spectrum almost within their grasp but allowed it to slip.

Newton observed the solar spectrum through a slit, yet failed to record the dark lines. Wollaston saw them in 1802, but evidently without bestowing upon them very careful attention. In 1815 Fraunhofer mapped some 600 lines, and actually noted the correspondence between the dark solar and the bright terrestrial lines of sodium, without interpreting the phenomenon; and it was not until 1859—just 50 years ago—that Kirchhoff solved the riddle, and opened the way for the great pioneers Huggins, Rutherfurd, Vogel and Secchi.

In 1882–3, Dr. W. N. Hartley contributed a paper to the *Journal of the Chemical Society* on "Certain Photographs of the Ultra-Violet Spectra," in which he drew attention to a certain connection between the atomic weights, the chemical properties, and the spectra of the elements, from which connection he deduced the composite structure of the atom—a deduction since abundantly verified—and in a series of papers on flame spectra he further showed that many metals yield in their spectra both lines and bands, the latter being subject to variations in structure, connected with the periodic law, which suggest a similarity in molecular constitution.

The fact that two distinct spectra are obtainable from the

same metal, under similar conditions of heating, has been variously attributed to the presence of two substances in the flame; to the reduction of vapor pressure; to the presence of large molecular aggregates; and to a difference in temperature.

In a monograph, recently received, on "Band and Line Spectra of the Same Metallic Elements" the author has given the results of a further investigation into the connection between these lines and bands, showing reason to believe that there are bands in the spectra of the elements having their origin in three conditions of matter, or, in other words, which are to be assigned respectively to the mass, the molecule, and the atom. The view that the banded spectrum of an element, yielding both bands and lines, is due to an aggregate of atoms—or a molecule—he considers inconsistent with the known vapor densities of the elements, or with the usual conception of the molecule of monatomic substances; although it becomes intelligible if the composite nature of the atom be admitted: "For the band spectra belong to the elementary atoms, and may be considered to be due to the vibrations, not only of the atoms themselves, but also of the component parts within the atom."

Assuming the arc and spark lines to be due to a greater amount of energy than that existent in the flame, and that this additional energy is in part contributed to the atom, it is possible that the parts of the atom are correspondingly excited, and that different groups of element, or different elements of the same group, would in accordance with their chemical properties, be variously affected, thus disclosing with greater or less facility line spectra varying in the number of lines, or in the relation of lines to bands; and this hypothesis agrees closely with observed phenomena.

Some experiments made by Dr. A. S. King, at the Pasadena laboratory, with the calcium spectrum are of great interest when it is considered what a large part the behavior of calcium plays in an interpretation of stellar types. Dr. King has shown that the *H* and *K* lines, within certain limits at least, are intensified by increase of temperature while the effect of pressure is com-

paratively slight. The line at λ 4227, on the other hand, is affected to a greater extent by a change in density than it is by temperature. Conclusions drawn in the belief that pressure was the dominating factor in determining the calcium spectrum may, therefore, require revision.

A new and perplexing phenomenon has been observed in connection with spectroscopic binaries, namely, the unequal periodic shift of lines of different elements in the same star. When it is remembered that the shift in question is supposed to be entirely due to the star's radial velocity, the baffling nature of this new enigma presented to the student of cosmic physics will readily be appreciated. The inequality of the displacement might suggest a physical cause did its periodic character not seem to rule such an explanation out of court. This secret also lies within the keeping of the Fraunhofer lines. Of one thing, however, we may rest assured, that no effort will be spared to force them to reveal it.

Not long before his death Professor Simon Newcomb completed his study of the mean motion of

THE MOON

based upon observations of eclipses and occultations covering a period of some 2600 years, that is, from B.C. 720 to the present time.

After considering the action of every known mass of matter upon our satellite he believed there was no escape from the conclusion that large fluctuations remain unexplained which may produce a change of annual motion of from 1″ to 0″·5.

These fluctuations may be divided into two parts, the first representing a period of from 250 to 300 years, and the second consisting of a series of minor disturbances with a principal term of 60 years, and in amplitude of 3″. In neither case, however, can it be said that the future history of such deviations will resemble the past.

"I regard these fluctuations," wrote Professor Newcomb, "as the most enignatical phenomenon presented by the celestial

motions, being so difficult to account for by the action of any known causes that we cannot but suspect them to arise from action in nature hitherto unknown."

The announcement by Professor W. H. Pickering that a

TRANS-NEPTUNIAN PLANET

is likely to be found recalls the discovery, following its prediction, of the planet Neptune in 1846. The history of the discovery of the outermost known planet of our system is an old story, but one that never fails in interest as it forms one of the most sensational pages in the story of the heavens.

Shortly preceding the actual discovery Sir John Herschel, addressing the British Association at Southampton, said: "We see it (the predicted body) as Columbus saw America from the shores of Spain. Its movements have been felt trembling along the far-reaching line of our analysis with a certainty hardly inferior to that of actual demonstration."

The influence of unknown disturbing forces is again felt within the solar system. Whether we are on the verge of fresh discovery, perhaps, the near future may decide.

In the investigations leading to the discovery of Neptune it was assumed that the orbit of the hypothetical planet lay in the plane of the ecliptic, and that its distance would be in accord with Bode's law. The mathematical problem was to determine its longitude. The idea suggested itself to Pickering that a graphical process might be invented which would disclose the position of outer bodies in our system, if such really existed, and after studying the perturbing influence of Neptune upon Uranus, Saturn, and Jupiter, he found that in each instance the disturbance was sufficient to have betrayed the existence of the unknown planet. In the graphical, as in the analytical method, the orbit of the unknown body is assumed to lie in the plane of the ecliptic, but its mean distance is based upon its orbit, which is deduced from the perturbations of all the planets used in the investigation. In determining the longitude the point of origin is fixed by the maximum positive disturbance of the known planet.

The result of Pickering's research is the following predicted elements for the suspected body :—

Epoch 1900 : longitude 105°·8 ; mean distance 51·9 ; period 373·5 ; mass (in terms of the earth) 2·0 ; angular diameter 0″·8; magnitude (if of same albedo as Neptune) 11·5 ; R. A. $7^h\ 47^m$; Dec. + 21°.

Professor Forbes has also been working for many years upon the problem of a trans-neptunian planet, his first paper on the subject having appeared in 1880. He was led to suspect the existence of a new planet in consequence of a study of the orbits of certain comets.

The comet of 1556 failed to return as it should have done if not interfered with by some external influence, and those of 1843, 1880 I. and 1882 II., are connected by certain resemblances in their elements, their aphelia lying in the same point of the heavens, and very near the aphelion of the comet of 1556. The question suggested by these facts is, whether this comet was broken up into three parts by the influence of some body beyond Neptune. The fact that three orbits intersected at one point was, at least, worthy of investigation.

The discovery of the predicted body, if it exists, will probably be rendered difficult, owing to the faintness of its light, but, on the other hand, improved star charts, and the aid of photography offer advantages not possessed by the searchers for Neptune. The fact that Bode's law has broken down beyond the orbit of Uranus is scarcely to be regretted since it led Adams and Leverrier astray by, at least, 25 per cent. in assuming the distance of Neptune.

It is a long journey from Neptune to Mercury, but the disturbing effect of unknown forces is felt at either extreme of the planetary system. Under the title "The Closing of a Famous Astronomical Problem," Professor W. W. Campbell gives a history of the search for an

INTRA-MERCURIAL PLANET.

Discrepancies between the observed and predicted positions of Mercury induced Leverrier to undertake an investigation of

the planet's orbit, and his results, published in 1859, showed that these discrepancies could not be entirely explained by the action of any known force, but that they might be accounted for by a body revolving about the sun within the orbit of Mercury, and lying nearly within the same plane. The mass of this body would, of course, depend upon its distance from Mercury. A ring of small bodies would explain the observed disturbance equally well, provided their total mass were sufficiently great.

Having in mind the mathematician's successful solution of a similar problem in regard to Uranus, astronomers were naturally impressed by the result of the investigation, and the search for the disturbing element became a live question in astronomy. As the new planet would probably never be far from the sun, its detection would be extremely difficult, and success could only be hoped for by observing it in transit across the disk of the sun or during a total eclipse. Many such discoveries were announced, but failed to sustain the test of a critical examination, and there is little doubt that the observers were deceived by mistaking sun-spots for the object of which they were in search.

With improved photographic apparatus, the search was resumed by Pickering and Abbot at the eclipse of 1901, and by Campbell's expedition in 1905, but with negative results. A further attempt was made by Dr. Perrine during the eclipse of 1908, but, notwithstanding, the fact that images of more than 500 stars were shown on the plates, no unknown object could be detected. As there are good reasons for believing that the orbits of any intra-mercurial planets would have come within the region covered by the exposure, and as objects as faint as the ninth magnitude would have been captured, Professor Campbell concludes that; "The investigations of Perrine, forming a part of the work of the Crocker eclipse expedition of the Lick Observatory, have brought the observational side of the intra-mercurial problem—famous for a half a century—definitely to a close."

Such a body, or bodies, may conceivably be found, but they could not be expected to meet the demands of Leverrier's calculation.

In addition to the disturbance of the orbit of Mercury Professor Newcomb found unexplained terms in the motions of Venus, the earth, and Mars, and various theories have been advanced in explanation. Seeliger has recently published some investigations regarding the space occupied by the material giving rise to the Zodiacal Light, and claims that there is sufficient mass in this material to account for the observed inequality in the motions of all four planets, his theoretical results agreeing closely with those observed by Newcomb. Campbell goes on to say: "We cannot assign this remarkable agreement between Newcomb's and Seeliger's results to fortutious chance, and it is scarcely possible to doubt that in the Zodiacal Light materials lie the causes of the discrepancies referred to. I have little hesitation in venturing the opinion that Seeliger's investigation marks an epoch in the application of Newton's law of gravitation to the motion within the solar system. At one stroke he appears to have removed a group of discrepancies which served as bases for many inquiries as to the preciseness and sufficiency of the Great Law. With all respect to Seeliger's genius and labor, however, scientific caution will value confirmation of his results by other investigators."

He then points out the renewed interest which direct observations of the Zodiacal Light will assume.

A question which is at present receiving considerable attention is that of

### THE ABSORPTION OF LIGHT IN SPACE.

Does the light from the stars, in its journey to the earth, suffer loss by absorption or scattering? In any attempt to arrive at a correct conception of the structure of the physical universe it is evident that such a probability must assume a position of the highest importance. As the thinning out of the stars appears to be approximately equal for corresponding distances in any direction it would seem to follow, if no loss of light occurs in transmission, that our sun occupies a central position in the visible

universe. Indeed, this was the chief astronomical argument advanced by Wallace in support of such a hypothesis.

Kapteyn, however, points out that the phenomenon may be equally well explained on the assumption that a determined loss of light is suffered, which, for the purpose of a working hypothesis, he suggests may be of the order of 0·016 mag., for a distance of 33 light years. This loss of light might depend upon two causes—scattering from meteoric matter, or absorption by gases in intersellar space. If the former, the loss would almost certainly be selective, being greatest in the region of shortest wave length ; if the latter, the effect would appear in the lines or bands of the spectrum, and Kapteyn sees evidence of this in the comparative spectra of certain stars examined by Miss Maury at Harvard College Observatory, which show a slight difference in the general absorption in the violet. It is, however, a task of great difficulty and uncertainty to assign the true source of such a difference among the many complex causes which may modify the intensity of the spectrum in any particular region.

As is well known, Huggins produced evidence to show that certain stars of class II. exhibit spectra more extended in the ultra-violet, than stars of the preceding type — a somewhat anomalous phenomenon — and one which he attributed to exalted temperature, but which Kapteyn enlists in support of the absorption theory, since solar stars are generally supposed to be nearer to us than those of the first type, whose shorter light waves might naturally be expected to suffer to a greater extent from impact with minute particles of matter in their longer journey to the earth.

The whole question is a difficult one, but of sufficient importance to lend interest to a correlation between spectra, proper motion and parallax. It is announced that the programme for the 5-foot reflector at Mount Wilson will include certain stars chosen with special reference to this problem.

Belopolsky, Nordmann, and Tikhoff attribute certain observed peculiarities in binary and variable stars to a scattering

of light in space, although this explanation does not meet with universal acceptance.

It should also be noted that the difference between visual and photometric magnitudes has been suggested as an evidence of light absorption. When the time of photographic exposure is prolonged in the ratio of five magnitudes, the gain is only four magnitudes, and Turner is of the opinion that Tikhoff has satisfactorily shown the discrepancy of photographs in violet light to be of cosmic origin.

The result of the investigations conducted at the Yerkes Observatory do not, however, bear out this interpretation, which Mr. Parkhurst considers doubtful in view of the marked effects produced by different plates and color screens; and Professor Frost failed to find, in an examination of the spectrograms of short period spectroscopic binaries, any evidence of difference in velocity for different parts of the spectrum. It will thus be seen that the question is in a very unsettled state, although the discussion is interesting, if for no other reason than as showing the inter-dependence of different lines of research, and how the smallest residuals in observational and experimental work may point the way to great generalizations. The width of an absorption line; a slight extension in the violet region of a spectrogram; or the difference in the time of minimum announced by the violet and red light waves from *Algol* may reveal the position of the solar system among the stars.

In the field of

COSMOLOGY

two important discussions of a critical character have recently appeared: one on La Place's theory of the solar system, and one on the fission theory of a rotating fluid mass.

In the address which I had the honor to read before this Society a year ago I ventured to draw attention to the weight of the evidence in favor of Darwin's earth-moon theory, and its extension to the binary systems. Almost simultaneously there appeared a paper in the *Astrophysical Journal*, by Professor F. R. Moulton, challenging the correctness of the Darwinian theory; and Dr. T.

J. J. See, who, in his "Evolution of Stellar Systems," had laid much stress upon the investigations upon which Darwin's theory was based, claims to have discovered a neglected element in the problem which necessitates, in so far at least as the moon is concerned, an entirely different view of the history of that satellite.

It has been shown that in the development of a rotating homogeneous fluid mass, of uniform density, but of varying rate of rotation, there would occur a continuous series of figures of stable equilibrim beginning with the sphere and ending with the pear-shaped figure; and the inference was that if the process could be followed to its conclusion the latter would divide into two distinct masses.

Professor Moulton raises two objections to this reasoning in its application to cosmogony: first that celestial masses are not homogeneous, and second that such masses do not change their rate of rotation except when their density, or distribution of density, changes. While theoretical discussions in support of the fission theory have regarded the rate of rotation as the only variable, the effect of alterations in density cannot be ignored, since the angular velocity of the mass, its gravitational constant and density, are all factors in the problem. Supposing the moment of momentum to be constant, as the laws of dynamics demand, the eccentricity of the figure, under the influence of contraction, is acted upon by two opposing forces—an increase of angular velocity, leading to increased oblateness, and an increase in density leading to a decrease of oblateness. Then follows a discussion of the conditions obtaining in the sun and planets—the existence of which is proof of their stability, — with the conclusion that earth and moon have not originated by fission from a parent mass.

In regard to binary systems Moulton claims that in the case of two equal masses originating by fission it would not be possible for tidal action to more than double their initial distance, and, therefore, that in such systems the original distances separating the two components cannot have been less than half their present

distances, and that in the case of such systems fission must have occurred, if at all, during the nebulous stage, the mass dividing into several fragments. The paper concludes with the suggestion that the time is ripe for an attempt to ascertain whether the theory that matter disintegrated under the influence of enormous sub-atomic energies will not account equally well with the accepted nebular theory for all the known phenomena : "That both aggregation and dispersion of matter, under certain conditions, are important modes of evolution, and that possibly together they lead in some way to approximate cycles of an extent in time and space so far not contemplated."

Such a conception does not appear unphilosophical, and the important questions raised by Professor Moulton should receive careful examination.

The object of See's investigation into "The Origin of the Planetary Systems" is to show that the circular orbits of the planets and satellites of the solar system is to be ascribed to the "secular action of the nebular resisting medium formerly pervading that system," and that these bodies have not been detached from the central masses now controlling them, as supposed by La Place, but have been captured from without, having their orbits "reduced and rounded up" by the cause named. He cites various evidences of the existence of such a resisting medium, and regards the low eccentricity of the orbit of Neptune as a clear indication that this body moved against a great resistance, the corollary of the existence of trans-neptunian planets being deduced. In further support of his views he enlists the criterion of Babinet that the planets and satellites of the solar system could not have been detached from their primaries ; also the mathematical work of Jacobi, Poincaré, and others, showing that satellites of the sun might pass under the influence of the planets. Jacobi's investigation of the problem of three bodies was based upon the assumption of motion in empty space. The introduction of a resisting medium would result in the particle, or satellite, which once revolved about both the sun and planet becoming either an inferior planet or the satellite of a planet. Under certain condi-

tions, when passing under the control of the planets, the motion would become retrograde. The earth never rotated much faster than at present, and could not have detached the moon, which came to us from space, being captured when at about double its present distance. It is, therefore, in all probability, still reducing its distance and this approach is the true cause of the secular acceleration of the moon's mean motion. Dr. See believes that the theory of the resisting medium will assume a place of the highest importance. The principal secular effect of this cause would be to decrease the eccentricity of an orbit, while the effect of tidal friction would be to increase it. Both influences may be at work in the physical universe, the former predominating in the case of a large central sun with small attendant planets, the latter in the case of two large masses such as the components of a binary system. As facts of observation we know the orbits of the bodies composing the solar system to be remarkably circular, while the orbits of double stars are noted for their great eccentricity.

Such are some of the sufficiently startling, and revolutionary ideas advanced by the author, an exhaustive discussion of which is promised in the forthcoming Volume II. of his "Researches in the the Evolution of Stellar Systems."

The lay reader, and perchance, even the professional reader may at times, in these days of rapidly multiplying astronomical theories, be inclined to ponder the words of Agassiz that "The temptation to impose our own ideas upon Nature still leads us away." Safety lies in a rigorous examination and testing of theory, with a prompt elimination of all that fails to meet the demands of observation and established law. As has been truly said, "The tendency of intelligent men is to approach nearer and nearer the truth by a process of rejection, revision, and invention."

In conclusion may I be allowed to enter a plea for the amateur study of astronomy. The amateur forms a link between the professional man of science and the general public, and how necessary such a link is may be gathered from the statement of Pro-

fessor W. W. Campbell, that among from thirty to forty thousand persons whom he had shown over the Lick Observatory during the period of his directorship, he found few acquainted with the simplest facts of astronomy, or with the nature of an astronomer's work ; and that the majority were unaware that the stars rose and set, or that there was any difference between the winter and summer skies. Although some effort may be necessary on the part of a layman to enable him to enter into intelligent sympathy with the work of the man of science, a little enthusiasm is a wonderful open sesame, and the intellectual reward amply repays the effort.

I close with the words of a great biologist, but words which are applicable to the pursuit of knowledge in whatever field. "The history of physical science," wrote Professor Huxley, "teaches (and we cannot too carefully take the lesson to heart) that the practical advantages, attainable through its agency, never have been, and never will be, sufficiently attractive to men inspired by the inborn genius of the interpreter of nature, to give them courage to undergo the toils and make the sacrifices which that calling requires from its votaries. That which stirs their pulses is the love of knowledge and the joy of the discovery of the causes of things sung by the old poet — the supreme delight of extending the realm of law and order ever farther towards the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run. In the course of this work, the physical philosopher, sometimes intentionally, much more often unintentionally, lights upon something which proves to be of practical value. Great is the rejoicing of those who are benefitted thereby ; and for the moment, science is the Diana of all the craftsmen. But, even while the cries of jubilation resound and this flotsam and jetsam of the tide of investigation is being turned into the wages of workmen and the wealth of capitalists, the crest of the wave of scientific investigation is far away on its course over the illimitable ocean of the unknown."

## SCIENTIFIC CRUMBS FROM EUROPE

By Otto Klotz

THE writer, as delegate for Canada, attended recently the third meeting of the Permanent Commission of the International Seismological Association at Zermatt, Switzerland. After the meeting a hurried visit was paid to a number of observatories and scientific stations before returning home. In the following are noted some of the crumbs picked up and which may be of general interest to the readers of the JOURNAL.

As a compliment to the Vice-President of the above association, Professor Forel, well-known for his study of the seiches of Lake Geneva, the meeting was held in Switzerland at the foot of the incomparable Matterhorn, the goal of all Alpine climbers, many of whom have found there an early grave.

Zermatt is something like a variable star, it almost vanishes from gaze for about nine months of the year.

Twenty-three countries compose the association, of which twenty were represented. The total number in attendance, delegates and other scientists was 42. Professor A. Schuster, of Manchester, presided at all the meetings. General meetings are held every four years and the Permanent Commission meets every two years. It will be remembered that the last general meeting was held at The Hague in 1907, at which a number of committees was appointed to report at the next or above meeting.

The one on "Bibliography" recommended that arrangements be made with the International Catalogue of the Royal Society for the publication in one volume of all papers on seismology.

The committee on "Catalogue," *i.e.*, for the publication of the catalogue for the earthquakes of 1906, held several meetings before a compromise was effected between different views on the

character of classification, regional or chronological. Considerable expense is involved in the preparation of a catalogue, hence its contents should serve scientific ends specially.

Makers of instruments had been invited to submit for The Hague meeting for competition a simple seismograph, with magnification 40 to 50 and costing in the neighborhood of seventy-five dollars. The testing of the apparatus was to be done at the Central Bureau at Strassburg, and the award was entrusted to five members of the Association. Three instruments were submitted and subsequently tested. The committee on instruments found: That the terms of competition had not been rigorously adhered to; that the price set for an efficient instrument was too low and not in keeping with the precision required in seismological work of the present day; that, however, good work had been done by the manufacturers for the above seventy-five dollars; and that no prize be awarded, but instead, the money available, some $250, be equally divided between the manufacturers, in a measure as compensation for their efforts. Emphasis was laid in the report on the fact that the first consideration of a scientific instrument is efficiency; the cost being of secondary consideration.

Nearly every country represented presented a report on its respective seismological service.

Of the numerous papers presented at Zermatt there were several of particular interest. Professor Hecker, of Potsdam, presented the results of his observations, extending over a period of nearly seven years, of the deformation of the earth under the influence of the moon. The instrument, (or instruments, for two were set up), used was a horizontal pendulum, in short a seismograph, placed in a well some 80 feet deep to eliminate as far as possible the heat effect of the sun.

It will be recalled that some thirty years ago Professor (now Sir) George Darwin and his brother Horace had attempted, but unsuccessfully, by means of a bifilar pendulum to observe and measure this same phenomenon. From theoretical considerations it is well known that the maximum horizontal force of the moon

is about one twelve-millionth of gravity, *i.e.*, if we had a pendulum 12,000,000 inches long, the moon would pull its extremity out of the vertical one inch. This is on the supposition, however, that the earth is perfectly rigid. We picture to ourselves then the bob of a freely suspended pendulum to follow the moon in its apparent daily motion around the earth, a phenomenon analogous to the tides of the ocean. As stated, the theoretical amount of motion can be accurately computed, so that, if we observe the actual displacement, it will give us by comparison with the theoretical value, a measure of the rigidity or yielding of the earth itself under the influence of the moon. This Hecker has successfully accomplished, and from his results it follows that the elasticity of the earth is somewhat greater than that of steel, a conclusion arrived at before, but by other means. The tide of the solid earth is from 4 to 6 inches. An interesting point brought out too was, that there is very little lag in the earth-tide, *i.e.*, that "high-earth" corresponds to the transit of the moon for any place, hence there is little internal friction.

Another interesting paper was that of Prince Galitzin on the determination of the azimuth or direction of the epicentre from the comparison of the corresponding amplitudes of two horizontal pendulums at a single station, one mounted in the N–S direction, the other in the E–W direction. He showed the inter-agreement of his deduced azimuth for a dozen known earthquake centres with the theoretically computed one. The method of obtaining the distance to an epicentre has, of course, for some time been readily available from the time interval between the different phases of an earthquake record; for instance, between the arrival of the first longitudinal waves and the first transverse waves; or the first long waves. So that, from the above contribution it would appear that from a satisfactory seismogram at any station the position of the epicentre, or place where the earthquake was, can be directly determined with considerable accuracy.

Of any individual question or subject discussed, the one on "Microseisms" elicited the most interest, and in which many members participated.

These microseisms, or earth tremors, have been observed practically over the whole globe, and are quite distinct from pulsations produced by earthquakes. They last for hours and days, and have a period of about $5^s$. The actual amplitude (half range) of the earth particles reaches 5 microns, or one two-hundredth of a millimetre. The question naturally arises, what produces these pulsations? Are they due to a constant stress in the earth's crust, which at times adjusts itself by a rupture along some weak line, along a fault, or are they produced by thermometric or barometric conditions of the atmosphere? Among phenomena of the latter we may consider winds and the position and movements of the area of low barometer. A very superficial examination of the facts eliminates the temperature effect, that is, the varying heat from day to day. The wind effect as shown by the microbarogram can readily be identified on the seismogram and is quite different from the microseisms.

The writer communicated the results of his investigation, extending over several years, which shows that the microseisms are due in the first instance to areas of low barometer, surrounded by steep gradients, *i. e.*, where the different isobars come close together; and in the second place, that such an area of low barometer is far more effective in producing microseisms when it is resting or passing over water, that is, the ocean. Experience shows that for the Atlantic coast the microseisms appear more strongly *after* the area of "low" has passed the recording station and has reached the ocean. Per contra, in Europe the reverse should obtain, as the general atmospheric movement between Canada and Europe is easterly, that is, the microseisms there should show themselves *before* the "low" reaches the land.

A special committee was appointed to further investigate this interesting problem and to that end it is probable that one or more instruments, especially designed for the purpose, will be set up on the seashore to record the pulsations of the water. The present mareographs or tide-guages are not adapted for the purpose, the time-scale being far too small, for one must be able

to read at least to five seconds of time on the record. A thousand marks or $250 was placed at the disposal of this committee.

The conference was successful in every respect. The members were all housed in the same hotel, and this enhanced the opportunity of "heart to heart" talks, which are really the most valuable assets the meetings of scientific men offer. The next meeting will be held at Manchester, England, in July, 1911.

Before leaving Zermatt we were given an excursion to the head of the valley — to Gornergrat. Here, at the end of the electric toothed-wheel railway, we stood at an elevation of over 10,000 ft., feasting on a panorama such as is reserved for few regions of our globe. Talleyrand has given us the epigram that "Language was given man to conceal his thoughts." The general belief is that "Language was given man to reveal his thoughts;" however, standing at Gornergrat, with the stupendous mountain chain from Mount Rosa to Dent Blanche, together with the fields of glaciers before us, we find that language utterly fails to convey in words the scene presented and the thoughts aroused by that grand spectacle.

In passing through Switzerland to Strassburg, the Central Bureau of the International Seismological Association, I cannot refrain from mentioning the immense "pot-holes" in the heart of the city of Lucerne. They were discovered by accident in removing the surface soil. I have seen pot holes in the Ottawa river and along the north shore of Lake Winnipeg, holes a foot or so in diameter, sometimes with the rounded stone that ground them out lying in them, but to see a hole over twenty feet in diameter, and there are a number of them, ground smooth and round by a cyclopean rock-cannon-ball was to me a marvel of the forces of nature as well as a page of nature's history of æons ago.

The earthquake station at Strassburg is well provided with many forms of seismic instruments. As is well known the object of an earthquake instrument or seismograph is to record the pulsations of the earth or movements of the earth particles. To effect this the horizontal pendulum is used, in which the bob or

heavy mass is supposed to be stationary during an earthquake but the frame and pier on which it is mounted respond to the vibrations of the earth. For the first impulse we, undoubtedly, get this ideal condition, but with continued pulsations, oscillations of the pendulum are induced so that our record becomes one compounded of the earth movement and that of the pendulum. To investigate this problem, of sifting the one from the other a massive "platform" was built at Strassburg upon which a seismograph can be placed for investigation of its behavior. The platform is suspended within heavy and rigid columns; and motions can be imparted to it of varying amplitude and period by special mechanism. The smallest amplitude is a little over one micron, or one thousandth of a millimetre ($\frac{1}{2500}$ of an inch). This motion is directly recorded on a revolving cyclinder, and also by the seismograph mounted on the platform. The motion of the platform is to imitate the motion of the earth particles in a quake. From the comparison of the two records of the same phenomenon we obtain the effect and amount of vibration of the pendulum itself. The platform has but recently been completed, and we may look forward to important results accruing from the investigation of different instruments and of the same instrument adjusted to various periods.

With our modern earthquake instruments of precision we obtain splendid records of earthquakes, but the hand-writing, except in its broad outlines, we are not yet able to read fully.

Before leaving Strassburg a visit was paid to the Meteorological station of which Professor Hergesell is director. Outside of the ordinary meteorological observations, the upper air is studied too by means of balloons. These are of rubber, filled with hydrogen and provided with recording barograph, thermograph and hygrograph, the whole encased in an aluminum case and weighing about three pounds. The barograph is an aneroid, the thermograph is, of course, metallic, and the hygrograph is a hair hygrometer. For the latter it is found that blond human hair is best adapted for the purpose. The hair before use is treated with ether to remove the oil. The ascent of a balloon

until it bursts takes from 30 to 45 minutes, reaching altitudes from 7,000 to 12,000 metres, say 4½ to 7½ miles. At that altitude, depending upon the isobars, is found the inversion stratum, *i. e.*, where a marked increase of temperature takes place with increase of height; for instance, the temperature being – 65° C rises with a further ascent to – 55° C, or 10° C (18° Fahrenheit) in the "Stratosphere." As soon as the balloon bursts from decrease of pressure from without, the apparatus falls. To lessen the rapidity of descent and the force of impact when reaching the ground, the balloon is provided with a parachute, which opens as soon as the fall begins. The apparatus may fall anywhere within a pretty wide area, but as it contains a request for its return to the station, they have all with one or two exceptions been recovered, although a year or more may elapse before they are accidently found in field or woods or even stream.

At Hohenheim, near Stuttgart, the earthquake station was visited. Here, in addition to the horizontal pendulum of the Omori type with air-damping, there is installed a Schmidt gravimeter for recording the vertical element of earthquakes. It has photographic registration, the light being supplied by a 4-5 c. p. Osram lamp fed from storage cells. Very few earthquake stations have their own time service but must rely on some near-by observatory. The comparison is made in various ways, in one case by regular visits to the observatory carrying a pocket chronometer; at others with a stop-watch in hand while listening to a signal sent by telephone; or again by sounder and telephone whereby the observatory clock-beats can be heard at the earthquake station while at the same time looking at the clock of the latter. In our own case, our standard mean-time clock controls the light of the photographic record, *i. e.*, the light is automatically cut off every minute, save the hour-minute, for two seconds. As the corrections to the clock are always less than a second we need apply no correction to our time-scale on the seismogram.

A visit was paid to Munich, ground made classic through the labors of Lamont on terrestrial magnetism as early as 1836; the magnetic observatory, however, was not built till four years

later. For field observations I found that Professor J. B. Messerschmitt used the Tesdorpf magnetometer outfit similar to ours. It was noticed that the magnets, when not in use, were kept between wooden hemi-cylindrical shells and those enclosed within a soft iron cylindrical box or tube. This is done to protect the magnets when travelling from the influences of dynamos and motors, whereby the constants of the magnets may be disturbed. This seems a wise precaution.

For the field observations, he prefers the pivot support instead of the fibre suspension for the determination of declination, as the former is less disturbed by the wind. For oscillations a half-seconds mean-time pocket chronometer by Kittel is used instead of the usual box-chronometer. Generally only deflections are observed in the field, and these compared with similar ones before and after at the base stations give data for deducing absolute values.

Observers in Europe have, as a rule, an advantage over us in giving the geographical co-ordinates for their magnetic stations in the field. The whole country being covered with a triangulation net to which is attached the cadastral survey, it is very easy to tie on to the latter and thereby obtain the required geograpical position.

Although the electric street-car line terminates not many hundred feet distant (about 200 m.) from the magnetic observatory no serious effect has yet been noticed. This is undoubtedly largely because the line of return current passes in a direction opposite to that of the observatory.

Secular variation was discussed with Professor Messerschmitt. Unfortunately this subject is still in such a state that even interpolation can be made only within narrow limits and extrapolation is unreliable. There is at present little hope that the magnetic elements for a given place can be computed in advance, say for ten years, with any degree of accuracy, as the astronomer predicts eclipses and other celestial phenomena. This will ever remain so until we can explain the cause of terrestrial magnetism, and the laws that govern such cause. Messerschmitt

uses the secular variation observed at the base-station Munich for other parts of Bavaria.

Heidelberg revisited. Here at the Königstuhl on whose summit is the astronomic observatory, a cordial greeting was given by Professor Max Wolf, who but a few days before (September 11) had re-discovered the famed and historic Halley's comet. The unitiated in looking at the photographic plate and seeing a small hazy patch, devoid of tail, devoid of brilliancy, devoid of anything spectacular, would be inclined to say "Is that all?" Yes, that's all. But what a triumph of intellect and human skill does it signify! Let us not forget the names of Crommelin and Cowell whose computations made it possible to point the telescope to the right spot in the sky for finding the wanderer. The photograph was obtained with the 72 mm. (28 inch) reflector, and an hour's exposure. The field covered was 1° 30′.

The isolation of an observatory on top of a montain or high hill, as here, has its compensation for the enthusiastic astronomer (although not for the wife and family) that he gets more clear nights than in the valley; for example, during the past year there were thirty-five more clear nights at Königstuhl than in the adjacent plain. When one views here the numerous domes and instruments, together with the very small staff of two or three, one deplores that some Mæcenas is not forthcoming to give the necessary financial support to so worthy an institution, and presided over by so devoted and eminent a scientist. Even the publication of observations is hampered for lack of funds. Among the galaxy of apparatus not noted on a previous visit some years ago, was the one for registering the discharge of atmospheric electricity. Two wires at right angles to each other on the roof intercept the wave, which is then led to the recording apparatus which includes a coherer. The record on the revolving drum indicates the intensity only, but not the direction or where the discharge took place.

The earthquake station of Professor Zeissig at Jugenheim near Darmstadt was visited, particularly to see the direct ink

registration of the 1200 kg. Wiechert seismometer; hitherto mechanical registration has been invariably on smoked paper. The registering pen for each component is a very fine glass capillary tube, the end of which is especially ground. The ink-well is in the axis of the pen and hence the pressure of the point is not affected by the ink supply. A red aniline ink is used and the pen gives a beautiful record. Specially smooth glazed paper is used to minimize the effect of friction, which in all mechanical registrations is one of the undesirable factors. The time scale is 7·3 mm. per minute, with 3-minute breaks. The clock-work, controlled by a conical pendulum, runs very evenly and uniformly, so that the graduated glass scale can be applied with confidence, as I found myself, anywhere on the record. The advantage of the ink registration together with a continuous roll, lasting about three weeks, is that one not only sees the finished record but can cut off at any time a part for immediate examination, say of an earthquake. The ink registration has but recently been introduced and Professor Zeissig was not yet in a position to express definitely the amount of friction of the recording pen. It will probably be found to be somewhat larger than for smoked paper. About the seismometer he has a suspended or hanging floor, so that walking about the instrument does not affect its zero. The station being within a few hundred feet of the railway line, every passing train leaves its record which, however, can never be mistaken for an earthquake. As the professor said, "I've got a check on every train and can tell whether it was on time or not." The Jugenheim earthquake station is a model of neatness in every respect.

Frankfurt lying en route, a few hours stay was made here to visit the "Ila" (Internationale Luftschiffahrt Association). It happened that during that time Zeppelin returned from the military manœuvres in Wurttemberg with his huge balloon, *Zeppelin III.*, and I with tens of thousands of other visitors had the pleasure of seeing this uncanny, unwieldy thing sail through the air, descend gracefully, and back into its shed with mathemati-

cal precision. It does not appear to the writer that this form for aerial navigation has a great future before it.

The earthquake station at Leipzig has one of the first of the Wiechert type of heavy (1000 kg.) astatic inverted pendulums. Unfortunately it is in the heart of the city, with machine shops and other disturbing elements surrounding it. During the day time, when industries are in full swing, the recording stylus behaves as if suffering from delirium tremens. At night and on Sundays there is more or less quiet. A neighboring tall chimney when under the influence of wind plays havoc with the surrounding earth giving at times deflections to the stylus of 5 cm.! An interesting record is obtained here on Sundays, when a chime of four church bells rings, a record of the concussions is found on the seismogram.

For lack of time, and besides having visited the scientific institutions at Potsdam near Berlin two years ago, a visit was only paid to Steglitz, a suburb, where Fuess has just finished for us a high class electric recording anemograph; recording direction, velocity and pressure. There are twelve wires for different pressures; four for direction; and one for velocity, making with the return wires, twenty all told, which will be led in a lead-covered cable from the tower, to be placed on the roof-walls of the observatory, to the recording apparatus within the building. At the time, the instrument was just being tested and its constants determined, and from appearances it promises to give full satisfaction. I was told that in the Harz mountains during the winter there are times when trouble is had with the large hemispherical cups of the anemometer due to the formation of "Rauhreif" on them. This is somewhat similar I think to our "glare ice" in winter. The rauhreif forming on the back of the cups may have the effect of turning the cups by wind the wrong way. This has happened too on the Säntis in Switzerland. At this factory I saw also a duplicate of the special barometer made for Professor Hecker for his gravity observations at sea; relative gravity being obtained by comparison of the atmospheric pressure and the boiling point of water. The main difficulty to

overcome in reading a mercurial barometer at sea is the effect of "pumping," *i. e.* of the jumping up and down of the mercury due to the motion of the ship and water.

At the Kiel Observatory the acquaintance of the director, Professor Harzer was renewed. The meridian circle with its housing is probably the most modern amongst this class of instruments. Its constants and idiosyncrasies have now been studied and determined and the results are now in press. When asked, if he had to build anew after his experience, whether he would make any changes, he gave a negative answer, which speaks well for the efficiency of instrument and housing. What strikes one immediately on entering the transit house is the very wide opening, two metres, in the roof. The building is of sheet iron with hollow walls. The difference of the temperature within and without is generally within a range of 1° C, the greatest recorded being 1½° C. The value of such uniformity is only too well appreciated by an observer. His azimuth marks, one north and one south, are about 60 m. distant, while there is a *mire* 7 km. (about 4½ miles) distant, available, however, only in the daytime. The annual rate of the standard clock (Strasser and Rhode) follows strictly a sine curve, and has no diurnal change of rate. The clock is under constant pressure. Although a driveway is close to the observatory no tremors are noted in the mercury when taking nadir observations. This is undoubtedly attributable to the sandy ground in the whole neighborhood.

I was informed of an interesting observation, and that was that there had been a slow change in azimuth and in one direction. But this was not a change of direction of the instrument only, but of the azimuth marks as well, in short, a "scholle" or block of the earth had slowly twisted about.

Continuing the journey homeward we pass through the stirring city and sea-port of Hamburg, where a brief call was made at the Seewarte (marine observatory). Here amongst other things all the ships' compasses are tested, and declination charts prepared covering the earth for use of navigators especially. The secular variation obtained at the base station, Wilhelmshaven,

near the mouth of the Weser, is used for all the German coast stations. When we come to deal with a country of the dimensions of Canada we require the observed secular variation for many stations scattered over the Dominion in order to deduce the declination for a given time at intervening stations.

A small brass screw of a declinometer was shown me, which had caused some mischief. It was found to contain some iron and had produced an error of 10′ in declination, illustrating how carefully all parts of magnetic instruments require examination in order to insure reliable results.

At Hamburg there is one of the best equipped earthquake stations, being the donation of a private citizen. It suffers, however, somewhat from the proximity of vehicular traffic. The time service for the station is elaborate and excellent; and the seismograms are studied with great minuteness.

At the adjoining city of Altona the workshop of Kittel was visited to inspect the mean-time half-seconds pocket chronometer being made for us for observing, in the field, oscillations of the magnet. The use of such a time-piece is an innovation. Hitherto such observations were made with a box-chronometer, all of which beat half-seconds, and which ordinarily pocket chronometers do not. I found the chronometer completed and ready to be sent to the marine observatory for testing for rate at different temperatures.

London was reached the following day and during the short stay here a visit was paid to the magnetic observatory at Richmond, where too the instruments for the meteorological service are tested. Some of the magnetic records of the south-polar expedition of the "Discovery" a few years ago were examined with much interest, especially those of declination which showed large values for the diurnal variation. It was learned that in dealing with the magnetic elements for Great Britain, the secular variation was assumed to be the same for an area of about 100 miles radius.

The great magnetic storm of September 25 occurred during

my stay in London, the manifestations of which were observed over the whole world, and have given rise to a renewed discussion of the origin of these storms. When the Cimmerian citadel is stormed by Lodge, Arrhenius, Birkeland, Hale, Störmer, Bauer and Chree, the effect of "light-pressure" should soon show itself.

A few days before sailing for Canada Shackleton's small ship, or steam yacht, the "Nimrod," anchored in the Thames along the Embankment, and the opportunity was taken to visit the now historic vessel. The ordinary traveller would say "cramped a bit." To me one of the interesting results of her antarctic explorations was that the south magnetic pole had been reached (January 16, 1909). After viewing in a neighboring building the large collection brought back, it is gratifying to find that a British expedition has returned from the Polar regions—from the Antarctic—laden not only with glory, which at best is only ephemeral, but with a rich harvest of scientific facts and specimens whereby our knowledge of the earth and of the earth's history is increased for the benefit of mankind.

# MEETINGS OF THE SOCIETY

## At Toronto

### GENERAL MEETINGS

The General Annual Meeting of the Royal Astronomical Society of Canada was held in the Rooms, 198 College St., Toronto, on January 4th, 1910. The retiring President W. Balfour Musson in the chair.

The Secretary's report indicated that during 1909, 15 meetings of the Society had been held in Toronto and that the Local Secretary at Ottawa, Mr. Carl Engler, reported 14 meetings held there; Miss Estelle Foy, Local Secretary at Peterboro, reported 11 meetings held in that Centre and E. H. Darling, Local Secretary, reported that 13 meetings had been held in Hamilton, making a total number of meetings of the Society held during the year of 53. A synopsis of all the meetings has been published from time to time in The Journal. The total membership numbered 443.

The Librarian reported the receipt of 788 publications, 168 maps received and 101 volumes bound during the year.

The Treasurer's Statement of Expenditures for 1909, was accepted. Messrs. J. G. Boyce and Wm. Bain were appointed auditors and subsequently reported a satisfactory audit of the accounts.

Estimates for 1910 were approved.

Mr. J. G. Boyce and Z. M. Collins were appointed scrutineers and the counting of ballots for the election of General

Officers and Members of the General Council for 1910 were proceeded with as provided for by the Constitution.

The scrutineers subsequently reported the results as follows :

Honorary President—W. F. King, C.M.G., LL.D., Ottawa.

President—Professor Alfred T. DeLury, Toronto.

First Vice-President—Professor Louis B. Stewart, Toronto.

Second Vice-President—J. S. Plaskett, B.A., Ottawa.

General Secretary—J. R. Collins, Toronto.

Recorder—Miss Elsie A. Dent, Toronto.

Treasurer—Chas. P. Sparling, Toronto.

Librarian—A. Sinclair, M.A., Toronto.

Curator—R. S. Duncan, Toronto.

Council—Joseph Pope, C.M.G., Ottawa ; H. B. Collier, B.A., Peterboro ; Rev. I. J. Kavanagh, S.J., D.Sc., Montreal ; Wm. Bruce, Hamilton : Lachlan Gilchrist, M.A., Toronto ; R. M. Stewart, M. A., Ottawa.

These elected members, with the Past Presidents of the Society and presiding officers of each Centre form the General Council of the Society. J. R. Collins, *Secretary.*

The General Annual Conversazione of the Society was held on January 18th, in Victoria College, Toronto. Hon. Dr. Pyne, Minister of Education for the Province of Ontario, was to have acted as chairman, but business of State prevented his attendance.

In the enforced absence (owing to illness) of the President, Professor DeLury, Professor L. B. Stewart took the chair.

The retiring President, W. Balfour Musson, delivered the address, choosing as his subject "Recent Discussion in Astronomy and Astrophysics."

The address appears as the first article in the present number of THE JOURNAL.

Mr. John A. Paterson, M.A., K.C., explained a number of new and interesting astronomical subjects with the aid of the projecting lantern.

## FINANCIAL STATEMENT
## THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

| 1909 | RECEIPTS, 1909. | | |
|---|---|---|---|
| Jan. 1 | Balance in Bank | 2051.15 | |
| | Reserve Fund in Bank | 256.25 | |
| Dec. 31 | Publications—Sales to date | 3.69 | |
| | Governors University of Toronto (50 subscriptions to JOURNAL) | 100.00 | |
| | Grant from Ontario Legislature | 600.00 | |
| | Grant from Dominion Government | 2000.00 | |
| | Grant from Corporation of Toronto City | 100.00 | |
| | Fees Collected to date | 604.50 | |
| | Interest on Deposits | 70.30 | |
| | | | $5785.89 |

| 1909 | DISBURSEMENTS, 1909. | | |
|---|---|---|---|
| Dec. 31 | Publishing JOURNAL to date | 1491.15 | |
| | Public Meetings | 123.95 | |
| | Books for Library | 101.25 | |
| | Chair for Librarian | 5.75 | |
| | Exchange on Cheques | 3.83 | |
| | Stationery, Stamps, etc. | 136.83 | |
| | Slides for Lantern | 2.85 | |
| | Salaries of Asst.-Librarian and Caretaker | 291.79 | |
| | Rent of Rooms from Canadian Institute | 200.00 | |
| | Grant to Peterboro Centre | 75.00 | |
| | Grant to Hamilton Centre | 150.00 | |
| | Grant to Ottawa Centre | 100.00 | |
| | Insurance Premium to "Queen City" | 13.000 | |
| | Gold Medal to University Toronto | 25.00 | |
| | Sundry Small Accounts | 46.73 | |
| | Bond purchased from Canada Permanent Mtge. Co. at 4% | 872.40 | |
| | Cash on hand in Imperial Bank | 2146.36 | |
| | | | $5785.89 |

CHAS. P. SPARLING,
*Treasurer.*

Examined and found correct,
(Signed) JAS. G. BOYCE,
WM. BAIN,
Toronto, February 12, 1910.

Mr. L. Gilchrist and Mr. A. F. Miller exhibited a number of apparatus in operation, illustrating interference phenomena and spectrum analysis. The exhibition included an ultra-microscope for viewing "colloidal particles" in solution, and other interesting things, after which refreshments were served.

The event was a very successful one, a large number of the members and their friends and invited guests being present, including many from distant points in the province.

J. R. C.

REGULAR MEETINGS

*December 7, 1909*—The meeting was held in the Chemistry and Mining Building of the University of Toronto in order that the paper of the evening, which was by Mr. Saul Dushman, B.A., on "Methods of Attaining and Measuring High Temperatures," might be illustrated by experiments.

Mr. Dushman first described the different methods of attaining high temperatures, such as the oxy-hydrogen flame, the electric arc, and thermite mixture. He then spoke of the various methods in use for measuring these high temperatures. Up to about 1500°C, the platinum resistance thermometer, and platinum-iridium thermo-junction may be used. The air-thermometer is more cumbrous and is only used in standardizing laboratories. Above 1500°, it becomes necessary to use *optical pyrometers*. The laws of radiation of hot bodies have been deduced by Stefan, Wien and Planck, and tested by Lummer and Pringsheim. For perfectly "dark bodies" they assume the following forms:

(1) Stefan's Law: $S = \sigma (T_1^4 - T_0^4)$; where S is the total intensity of radiation emittted, $\sigma$ is a constant, and $T_1$ and $T_0$ are the absolute temperatures of the emitting and receiving bodies respectively. The Fery pyrometer is an application of this law.

(2) The *intensity* of each of the various radiations emitted by a hot body is a more complicated function of both $\lambda$ (the wave-length) and T given by Wien's formula. This relation is

applied in the Wanner and the Holborn and Kurlbaum pyrometers.

(3) The intensity-curve at any temperature, that is, the intensity of each radiation plotted as a function of the wave-length shows a maximum value ($E_m$) at a definite value of the wave-length ($\lambda_m$) and the following relations are found to hold true: $\lambda_m T = A$, and $E_m T^{-5} = B$.

By means of these relations and similar relations for the radiations emitted by a platinum surface (which emits at any temperature a less intense radiation than a dark body) it has been found possible to assign maximum and minimum limits for the temperature of various hot bodies. The temperature of the sun as thus determined is between 5260° and 5880°C.

The lecture was illustrated by numerous lantern slides as well as experiments. With the electric arc Mr. Dushman showed the melting of copper and iron, the reduction of iron ore and the formation of calcium carbide, and an experiment with *thermite* mixture illustrated the formation of iron from iron oxide and aluminium powder.

A hearty vote of thanks was tendered Mr. Dushman for the very interesting lecture and especially for the striking experiments.

*December 21*—Mr. R. Hamlyn, 445 Church St., Toronto, was elected a member of the Society.

Mr. J. F. Sharpe referred to an interesting spectacle seen on the previous evening, when the moon, Saturn and Mars formed a conspicuous triangular figure in the heavens.

The paper for the evening was by Professor Percival Lowell, and dealt with "Photographs of Jupiter, made at the Lowell Observatory, 1909." The photographs referred to were made between the dates March 10 and May 20, by Professor Lowell and Mr. E. C. Slipher. Photographic prints enlarged about two diameters accompanied the paper and exhibited considerable detail. Accurate measures of the positions of the belts were given, and showed that the latitude of the same belt varies somewhat with the longitude of the planet. This fact was illustrated

by several belts. Reference was also made to dusky hoods covering both poles, presenting a stippled effect, in contrast to the striped character of the rest of the plate.

Especial attention was drawn to the wisps lacing the bright equatorial belt, discovered by Mr. Scriven Bolton. They consist of a remarkable set of irregular narrow dark streaks proceeding from triangular black spots in the northern edge of the south tropic belt and running thence, usually at an angle of 45°, to similar spots in the southern edge of the north tropic one. They seem to be rents in the bright clouds.

Another noteworthy feature of the belts is the paired propensity of the tropic ones. This results from a darker tone at their edges than in between. Saturn shows a like arrangement, which is an index of the physical condition of these planets.

Interesting deductions regarding the physical condition of Jupiter were made by Professor Lowell. He concludes that Jupiter is in a midway state between the sun and the earth. He does not shine perceptibly by his own light, which is but a brick-red glow at best, lacking the essential quantity of a sun, luminosity. Not less does he fail of those conditions which enable a planetary mass to evolve into a world. He is still a seething chaos of indescribable turmoil. Too hot to be the one body, too cold to be the other, he stands between in a state essentially his own.

Professor Lowell's paper will appear in full in the next issue of the JOURNAL.

The address was followed by an interesting discussion, in which various members took part. Mr. Elvins' remarks were especially interesting, as he gave reminiscences of his observations of Jupiter made some thirty years ago, and stated that he had at that time come to the conclusion that there was at least one more satellite of the planet than was at that time known.

*February 1, 1910.*—First Vice-President, Professor Stewart, in the chair.

After a number of communications had been read, several members reported having observed Comet *a* 1910.

Rev. Robert Atkinson, of Chesley, Ont., had independently observed the comet on the night of January 21st, from Newfoundland where he was then visiting.

Mr. G. J. Hoyle, of Cannington, Ont., had observed it from that place on the night of January 24th. The skies in the neighborhood of Toronto had been overcast nearly all the time the comet was in position for observation and it had not been seen by many. Mr. Muir and Mr. Elvins reported having seen it however on the evening of January 29th.

Mr. Muir then took the chair and Professor Stewart gave the paper for the evening on "Astronomical Determinations of the Terrestrial Pole."

The lecturer described the ordinary methods of finding latitude and longitude available for the explorer or the navigator, and shewed the difficulties attending their application in high latitudes. It was shown that while no special difficulty need be experienced in determining latitude as its value approaches 90°, the determination of longitude becomes increasingly difficult, and finally indeterminate, as is to be expected on general considerations. The use of the sextant and artificial horizon and the transit were described, showing the advantages of the latter instrument, especially in high latitudes, where the use of the former instrument must become impossible in some circumstances.

*February 15.*—The President in the chair.

J. H. Mason, 180 Richmond St., West; J. D. Farquhar, 88 Wright Ave., Toronto, were elected members of the Society.

Under "Observations" Professor Chant gave a historical sketch of Comet *a* 1910, the fact of sodium being observed in its spectrum being noted.

Mr. Muir drew attention to peculiar curvations of the orbit of Halley's Comet when projected on the star sphere.

Prefessor Stewart reported having observed Halley's Comet from his observatory, with his transit instrument of 2¼-in. aperture at 8 o'clock on the night of February 10, using a power of eighty. The object appeared as a blurred star of the 7th or 8th

magnitude in the position predicted by its ephemeris. Professor Chant had also observed it on the same night with 4½-in. aperture.

Mr. J. Frederick Sharpe gave the paper for the evening entitled "The Winds of the Ocean." The various trade winds and other more or less regular atmospheric currents were described, and in well chosen language the paper gave a vivid account of storms at sea, drawn from his personal experience in various waters as an officer of a sailing vessel of forty years ago.

E. A. D.

### At Ottawa

*December 21, 3 p.m.*—Mr. James White was elected a member of the Society.

Dr. W. F. King gave a paper on "The Gyroscope and Gyroscopic Action." In studying the dynamics of extended bodies we have, in addition to the motion of translation about which we are alone concerned in particle dynamics, the motion of rotation and the conservation of energy of motion or inertia. Motions of rotation can be combined by the "parallelogram of rotations." The moment of momentum or of inertia of a body about an axis and the principal axis of a body were defined by Dr. King and these principles applied to explain what would happen if a poorly balanced fly-wheel were suddenly released. This itself was used to illustrate the cause of the variation in latitude of points on the earth.

A gyroscope was then set in motion and several experiments made with it. By combining the motions of rotation by the parallelogram of rotations referred to above, Dr. King showed how it lifted a weight suspended at the end of the axis, and explained also how its motion of precession varied inversly as its axial rotation.

Another way of considering the gyroscope was as a body having internal energy. As far as the internal force was concerned, it must continue either at rest or in uniform motion in a straight line. In this connection the problem of how a cat,

dropped in any position, is always able to light on its feet was discussed and explained, the explanation being illustrated by a series of photographs. An explanation was given for the fact that a coin or a school-boy's hoop keeps upright, and for the fact that a paddle-wheel steamboat is easier to steer in a sea than one having a propeller.

The applications of the gyroscope in steadying the saloon of a boat, in steadying gun platforms at sea, in providing an artificial horizon, for steering torpedoes, as a substitute for the compass and as a means of balancing the mono-rail car were then explained. An important part in the latter was the way in which the friction of the gyroscope axis had been made use of to automatically balance the car.

*January 13th, 1910, 3 p.m.*—Messrs. M. P. Whelan, Militia Department, and E. W. Nesham, Y.M.C.A., Ottawa, were elected members of the Society.

Mr. W. M. Tobey, B.A., gave a paper on "A Comparison of Astronomic and Geodetic Survey Data, and the Deduced Truths therefrom."

The latitude and longitude of a place as determined astronomically seldom agree with the latitude and longitude as determined by referring it geodetically to some other point whose position is known. Before we can learn anything of the truths locked up in the survey data we must account for this difference. The first way which naturallly suggests itself is to apply the corrections to the astronomic co-ordinates due to the local attractions which deflect the plumb-line. It is found, however, that a careful calculation of all the effects of hills, plateaus, seas, valleys, etc., upon the plumb-line, when applied as a correction to the astronomic position gives a discordance considerably greater than before. Mr. Tobey pointed out that the reason of this was that we have considered things on the surface only without considering that there may be regions of different density beneath. If we assume that at a depth of $h$ kilometres below the surface there is a state of equilibrium among the interior forces of the earth, then upon equal areas of the surface of this sphere of

iseostacy there must be equal pressures ; hence volumes of outer crust resting on these equal areas must have equal weight. To make this possible there must be beneath every mountain a region of less than average density which will exert less pull upon the plumb-bob than the surrounding region, *i.e.* the plumb-line will be deflected away from the mountain instead of towards it, and of course corrections applied on this theory being of opposite sign to those first applied will give results tending to reconcile the discordances referred to above. Mr. Tobey gave a number of examples in which corrections were applied according to the two methods, showing the close agreement of geodetic and astronomic positions when the latter were corrected according to to the theory just outlined.

Returning now to the astronomic and geodetic latitude of a place, the difference may arise from the following causes :

(1) An error in value assumed for $h$, the depth of complete iseostacy.
(2) An error in value of latitude of starting point of geodetic survey.
(3) An error in value of longitude of starting point of geodetic survey.
(4) An error in value of azimuth of geodetic lines.
(5) An error in value assigned for earth's radius.
(6) An error in value assigned for earth's eccentricity.

By expressing the above statement in algebraic language we get an equation, and from a large series of observations we get a great number of equations ; and by the method of least squares we can get the most probable value of the quantities involved. This method applied to about 500 equations of the Coast and Geodetic Survey of America gives a value of $h$ very closely agreeing with the values obtained by other independent methods. The most probable values of $h$ and of the earth's diameter and eccentricity having been found it remains to apply corresponding corrections to the latitude as before determined.

In concluding, Mr. Tobey pointed out that to carry out such a programme results were needed over a large territory.

In the interesting discussion and comment which followed Mr, Tobey's paper the different values of $h$ as obtained by different methods were given by Dr. King.

*January 27th, 8 p.m.*, in Y.M.C.A. Hall.—Mr. J. S. Plaskett, the vice-chairman, introduced Dr. Otto Klotz, who gave a paper on "Our Earth in the Universe."

Dr. Klotz prefaced his lecture by thanking the Directors of the Y.M.C.A. for the privilege of using their hall, which was not only a very beautiful one, but was exactly suited in size to the requirements of the Society.

Every thoughtful observer looking at the sky asks himself what the countless stars are and what changes they are undergoing. Dr. Klotz answered these inquiries by referring to the recurring cycle of changes going on in the case of water on the earth,—vapor, clouds, rain and seas. So in the universe the stars and worlds go through their endless cycle of restless change.

Beginning with the solar system, which includes the parent sun, the planetary children and the satellite grandchildren, Dr. Klotz outlined the theory of evolution of our earth from an incandescent state cooling to a spheroid with a tendency to assume a tetrahedral form, as was evidenced by the conformation of land and water on our globe, as well as by the lesser value of gravity in the southern hemisphere. The production of water-vapor was an important epoch in the earth's history. The first germs of vegetation may possibly have come from some other planet, since there existed germs of life so small that the effect of light pressure on them was greater than the effect of gravity; consequently they were wafted away into space.

Dr. Klotz then explained the fact that polar vegetation was of a tropical nature in past ages, not by assuming some change in the inclination of the earth's axis to its orbit, nor by a change in the eccentricity of this orbit; but he showed that a change in the chemical composition of our atmosphere would increase the absorption of heat from the sun's rays. An increase of carbon dioxide from 0·3 to 0·9 per cent. would raise our temperature 16° F., an amount sufficient to cause all the changes referred to. This increase of carbon dioxide might have been caused by increased volcanic activity.

Dr. Klotz then spoke of the compass, its daily variation in declination, and the relation between terrestrial magnetism and the magnetic disturbances on the sun. The aurora was also related to these disturbances. Closely relating to magnetic phenomena was lightning.

Having treated of things in the heavens and on the earth Dr. Klotz next spoke of things beneath the earth. The interior of the earth is not fluid, since its flattening is not that of a fluid spheroid rotating at the speed of the earth. Neither is the earth a perfectly rigid body, as is shown by the "earth tides" of from 4 to 6 inches at full moon. The great means of studying the earth's interior is the earthquake tremors. Dr. Klotz showed how a study of the time of travelling of the different tremors sent out by every earthquake gives us a knowledge of the distance to the centre of disturbance and also a knowledge of the path through which the tremors came. They proved beyond a doubt that the interior of the earth was solid.

A slide was shown giving the areas on the earth's surface subject to earthquakes; and in conclusion Dr. Klotz gave a striking review of the vast region revealed to the knowledge of man.

*February 10, 3 p.m.*—Messrs. A. Lighthall, S. D. Fawcett and C. R. Coutlee were elected members of the Society.

Mr. J. J. McArthur, D.L.S., read a paper entitled "How the Camera is Applied for Topography." First, a brief account was given of how the camera came to be used in surveying. To Dr. E. Deville, Surveyor-General, belongs the credit of suggesting it.

In 1886 Mr. McArthur was commissioned to make a topographical survey of the country through the Rocky Mountains adjacent to the new C.P.R.; at the same time Dr. Klotz was to make an astronomical traverse of the line. During the season's work Dr. Deville had an experimental survey made by the camera in the neighborhood of Banff. In spite of the fact that the instrument was not very well adapted for the work, the results were so gratifying that next year two parties were sent out.

The experience gained the previous year suggested a camera of special construction, which was designed by Dr. Deville, and which is in use at the present time. It was also found that plates were necessary instead of films in taking photographs. Over 500 square miles of territory were surveyed in this season.

Later on the method was adopted by Dr. King in obtaining topography along the international boundary. Mr. A. O. Wheeler has also made extensive surveys in the Selkirks and the Rockies, and by presenting his information in attractive form has done much to advertise Canada. Photo-surveying has also been used by Mr. Dowling, of the Geological Survey. The Japanese and Russians have also applied the method.

Mr. McArthur then described the camera used. It had a constant focal length and was accurately levelled. When photographs had been taken the next step was to plot the map. To do this it was necessary to find the focal length of the camera, to find the horizontal plane and the vertical plane perpendicular to the picture plane. The method of doing this was explained graphically. The method of obtaining the altitude of the different features in the picture was then explained. As the survey was usually based on a trigonometrical survey which furnished points of known altitude, a check on the accuracy of the photographs was at once obtained. The next step was to orient the view.

The plotting of a map from the photographs always showed up any error made in the work. If two plates were in error, a third one having several points in common would always reveal this error.

An important part of the work was the selection of the camera stations. These should be at points whose altitude could be accurately determined, and the views should overlap so as to have many points in common.

Mr. McArthur then discussed the relative merits of the plane-table and camera in obtaining topography. The plane-table was preferable in a country having little relief, while in a rough country affording many points from which extensive views could

be had the camera was better. In our country the best results would be obtained by using both. A slide was shown of a tract of country mapped out, first from plane-table surveys and secondly from photographic surveys. The agreement was very close. The time saved by the use of the camera in this survey was also pointed out. C. E.

### At Peterborough

*January 10, 1910* -The local officers for this Centre were elected at this meeting. Rev. D. B. Marsh, who has been the efficient president of the Centre since its organization, requested that he be allowed to retire in favor of the Vice-President, Mr. H. B. Collier. In accordance with this request Mr. Collier was thereupon elected to office of president with the following officers to form the Council or governing body; Vice-President Mr. H. O. Fisk; Secretary-Treasurer, Dr. Marsh, and Councillors T. A. S. Hay and D. E. Easson.

The reports of the various officials covering the work of the Society during the past year gave evidence of a very satisfactory state of affairs. The lecture department showed that Peterborough has been favored with the presence of a number of very prominent astronomers, and that the result of their lectures has been most gratifying. While the attendance has been very fair indeed, some improvement can undoubtedly be made in this feature. Considering the literary importance of this city and the eminence of the lecturers that are being brought to the city by the society, the meetings should be crowded instead of having just a "fairly large attendance."

The lecture of the evening was by Dr. Marsh on the subject of "Stellar Evolution," and proved a most interesting one.

It was illustrated throughout with lantern views and proved very entertaining as well as instructive.

*February 1.*—The following were elected members of the Society:

A. G. Carruthers, 239 Burnham St., Peterborough.

Frank Adams, 50 Robinson St., Peterborough.

Rev. E. A. Langfeldt, Ph.D., St. Luke's Rectory, Roger St., Peterborough.

Richard B. Rogers, B.A.Sc., C.E., 147 Hunter St., Peterborough.

G. C. Wainwright, Mgr. Bank of Ottawa, Peterborough.

Hugh Waddell, Monaghan Road, Peterborough.

Rev. Dr. Marsh gave a paper on "The Keys by which the Heavens are Unlocked." This was an attempt to explain how the dwellers on the earth obtain information regarding other worlds and the great universe about us. On account of the extent of the subject it was divided into two parts, the present one dealing chiefly with earlier methods of observation. The behavior of light was explained, and various instruments, such as the transit, reflecting and refracting telescopes (with their various kinds of mountings) were described and their uses illustrated. Stationary instruments, mounted on solid foundations were described. The subject of refraction was briefly considered as an introduction to the next lecture, when the spectroscope and other recent and improved instruments will be discussed.

At the close of the lecture the President gave some interesting information regarding Comet 1910*a*, and also some facts about Halley's Comet—chiefly in regard to the possibility of the earth passing through its tail. H. B. C.

### At Hamilton

*December 22nd, 1909.*—The following have been elected members of the Society since October 22: Mrs. H. B. Sexton, H. L. Smith, Joseph Pim, Robert Thomson, Mrs. G. F. Glassco, F. M. Robinson, W. A. Child, M.A., J. M. Williams.

The President in opening the meeting referred to the great loss the Society had suffered in the death of Mr. Chas. G. Milne, B.A.Sc. Mr. Milne had been a member of the Hamilton Society since its organisation and had always taken a deep interest in its work.

Mr. J. M. Williams was the speaker for the evening, his subject being "Looking Up and Looking Down," and under

this title he exhibited a planetarium, the models composing it being of his own construction. Mr. Williams has many original ideas and his illustrations of the motions of the various bodies of the Solar System were probably the most realistic ever given before the Society.

At the close of the lecture he presented all his models to the Society which were gladly accepted and a hearty vote of thanks was tendered him.

*January 14, 1910.*—Mr. Vincent Lightheart was elected a member of the Society.

In the unavoidable absence of Miss Elsie A. Dent, of Toronto, who had promised to speak on "Star Geography," the local president (Mr. G. Parry Jenkins) addressed the members on the subject "Is the Moon a Dead World?" Owing to the severe storm which had been raging all day it was a surprise to see so many turn out. In popular language Mr. Jenkins traced the history of our satellite from the time it broke away, according to Professor Darwin, from the earth, and then rotated on its axis in a period of three hours, to the present stage of its existence, practically devoid of all atmosphere and water, with its physical energies completely spent, in fact a cold, dead world, most probably a prototype of our own earth in the far distant time—

> "When the old hulk we tread shall be a wreck,
> A slag, a cinder, drifting through the sky,
> Without its human crew."

A most interesting discussion followed in which the following members took part—Rev. J. J. Morton, Messrs. W. A. Robinson, W. Bruce and A. E. Freeman.

E. H. D.

*January 28.*—The paper for the evening was on "The Artistic Side of Astronomy," by Mr. Wm. Bruce, J.P. The popularity of our veteran vice-president with a Hamilton audience was unmistakable. The lecture room was crowded with members and friends to hear this the second part of Mr. Bruce's paper.

In a very carefully prepared essay he deftly wove together many astronomical facts with true artistic feeling, as seen to the inner student of nature, until a glorious and harmonious unity of heaven and earth was presented.

Owing to the various officers and members of the Centre being represented by the lecturer as adding their quota of information and sometime humor to the subject dwelt upon, this mode of treating it—the "Brucian" method—added a good deal of local zest to the whole proceedings.

At the close many expressions of appreciation for the excellent address were voiced by Mr. W. A. Robinson, Rev. J. J. Morton and others.

It was reported that one of our members, Mr. Robert Thomson, had seen Comet 1910*a* with the naked eye for a few minutes during a break in the clouds on January 25, but as far as could be gathered the first member of our Society to get a glimpse of our visitor was Father Brady who saw it in Montreal on January 22.

*February 11.*—At this meeting the election of officers for the present year took place, resulting as follows:

Local President, G. Parry Jenkins, F.R.A.S.

1st Vice-President, Wm. Bruce, Elmwood Observatory.

2nd Vice-President, E. H. Darling, A. M. Can. Soc. C.E.

Secretary, T. H. Wingham, B.A.Sc., 174 Aberdeen Ave.

Treasurer, A. T. Neill, City Hall.

Councillors, Rev. R. E. M. Brady, D.Sc., W. A. Robinson, Rev. J. J. Morton.

Professor A. T. DeLury, Toronto, the President of the Society, was to have given a lecture on "Comets," but owing to illness was unable to be present. He was, however, well represented by Professor C. A. Chant, who lectured on the same subject. He covered the history of these, our infrequent visitors, from the time when they were considered merely "sublunary emanations" up till the present scare over the cyanogen lines recently observed in the approaching Halley's Comet.

In the course of the lecture he told of Halley's great work and his connection with Newton in determining the orbits of comets and tracing their former appearances far back into early history.

At the close of the lecture a hearty vote of thanks was passed on motion by Inspector J. H. Smith, seconded by Mr. W. A. Robinson, which was claimed to be all the more hearty that Dr. Chant had rumoved all fear of our sudden extinction by stating that all the cyanogen contained in the portion of the tail liable to be intercepted by the earth's atmosphere, even supposing we passed through the same, could be put in a pill box.

T. H. W.

# NOTES FROM THE DOMINION OBSERVATORY

## Astrophysics

The spectroscopic binary *φ Persei* which has been under observation here for some time, and whose orbit is now being determined by Mr. J. B. Cannon, is peculiar in certain respects, which have seemed to me worth referring to here. As is well known, the spectrum contains bright lines or bands of hydrogen, and in the centre of the bright band there is a fairly well defined absorption line assumed as due to hydrogen, and on which the measures of radial velocity chiefly depend. Besides the four $H\beta$, $H\gamma$, $H$ , $H\epsilon$, the only other line measured has been the calcium $K$, although the helium $\lambda$ 4472 has appeared on some plates. It may be noted that in the plates in which $K$ was measured the velocities obtained from it have agreed with those from the hydrogen lines, thus justifying the assumption made above.

The character of the hydrogen emission and absorption seems to depend to some extent on the position in the orbit, and a further peculiarity is a very decided hump in the descending branch of the velocity-curve, very similar to that appearing in the ascending branch of the velocity-curve of the variable and spectroscopic binary star *W Sagittarii*.* The superposition on the primary velocity-curve of a secondary sine curve of half the period does not produce very satisfactory agreement with the observations, although effecting very marked improvement over any curve due to simple elliptic motion. It seems as if this must be added to the unsolved problems rapidly accumulating in spectroscopic binary work.

* *Astrophysical Journal*, xx., p. 149.

The emissive character of the spectrum, the probable dependence of its character on the phase in the orbit and the charcteristic hump above referred to, lead to a strong suspicion that the light of the star may be variable. It is not likely that the range is great, but it may be worth while testing by those who have sufficiently sensitive photometric apparatus.

The orbit of the spectroscopic binary $\tau$ *Tauri* has been completed by Mr. T. H. Parker and will be published shortly. This star is chiefly remarkable in the shortness of its period, about one and a half days, and in the extreme diffuseness of the lines of its spectrum, which has rendered the measurement of the plates uncertain and the determination of the elements of the orbit difficult.

Some further plates have been obtained and a least-squares correction added by Mr. W. E. Harper to the orbit of $\alpha$ *Draconis*, the first spectroscopic binary orbit obtained at the Dominion Observatory. The corrections to the former values are comparatively small. The principal details will shortly be published by Mr. Harper.

It is much to be regretted that the very unfavorble weather we have experienced for the past three or four months should have continued during the brightest phase of the recent comet *a* 1910. It was only visible to the unaided eye here on three nights, and haze near the horizon interfered considerably even then, preventing as successful photographs as would otherwise have been obtained. Reproductions of those obtained by Mr. R. M. Motherwell are given in another part of this issue.

J. S. P.

## COMET NOTES

(See Plates I.-IV.)

### HALLEY'S COMET

Nov. 9, 1909—Seen for first time at the Dominion Observatory. Estimated magnitude about 13.

Nov. 23—Estimated magnitude about 12·5; centre rather star-like.

Nov. 30—Estimated magnitude about 12; much the same in appearance as on November 23.

Dec. 11—Estimated magnitude about 12.

Dec. 16—Same as on December 11; diameter 15″.

Jan. 4, 1910—Exposed two hours with Σ Plates; no sign of a tail on the negative but side of comet towards the sun was more sharply defined than the opposite side.

Feb. 10—Exposed 1h 40m, Σ Plate; tail of about ½° showing on negative (see Plate IV.). Comet was visible in field glasses of power 8.

### COMET 1910 A

This comet was first observed here on January 25d 10h 30m (G.M.T.) with the aid of field glasses. A few minutes later it was visible to the naked eye.

The following approximate position was obtained from circle settings of the 15-inch telescope.

Jan. 31d 11h 45m

$$\alpha = 21^h\ 37^m\ 40^s$$

$$\delta = +\ 2°\ 38'$$

The exposures are given on the plates.

### POSITION OBSERVATIONS OF HALLEY'S COMET

| G.M.T. 1909 | | | | No. of Comparison | $\triangle\alpha$ | $\triangle\delta$ | $\alpha$ (apparent) | $\delta$ (apparent) | log p. $\triangle$ $\alpha$ | log p. $\triangle$ $\delta$ | Star |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | d | h | m | s | m s | ′ ″ | h m s | ° ′ ″ | | | |
| Nov. | 30 | 15 | 56 | 24 | 8-8 | −1 3·04 | −2 4·9 | 4 29 21·85 | 15 55 35·0 | 0·187 *n.* | 0·638 | 1 |
| Dec. | 11 | 13 | 2 | 4 | 8-8 | 0 53·12 | +3 15·9 | 3 43 2·31 | 14 45 27·7 | 0·567 *n.* | 0·676 | 2 |
| Dec. | 16 | 20 | 8 | 18 | 8-8 | −0 1·95 | +4 49·7 | 3 19 29·16 | 14 00 3·5 | 0·803 | 0·766 | 4 |

### MEAN PLACES FOR 1909-10 OF COMPARISON STARS

| Star | $\alpha$ | | | Reduction to Apparent | $\delta$ | | | Reduction to Apparent | Authority |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | s | ° | ′ | ″ | ″ | |
| 1 | 4 | 30 | 21·50 | + 3·39 | 15 | 57 | 29·4 | + 10·5 | A. G. 1231. |
| 2 | 3 | 43 | 51·56 | + 3·87 | 14 | 41 | 58·7 | + 13·1 | A. G. 1108. |
| 3 | 3 | 20 | 21·10 | | 13 | 46 | 1·9 | | A. G. 1004. |
| 4 | 3 | 19 | 27·85 | + 3·26 | 13 | 54 | 59·5 | + 14·3 | B. D. 13°·542: Micrometer Comparison with (3). |

R. M. M.

THE SEISMOGRAPH—BOSCH PHOTOGRAPHIC, 200 GRAMMES

THE following earthquakes have been recorded since the last notes were sent.

| 1909 | | N–S Component | E–W Component |
|---|---|---|---|
| December 4 | | h m s | h m s |
| | 1st P. T. | 1 21 30 G.M.T. | 1 21 29 G.M.T. |
| | 2nd P. T. | 1 27 11 | 1 27 07 |
| | P. P. | . . . | 1 31 |
| | Max. | 1 38 | 1 38 |
| | End | 2 00 | 2 10 |
| December 9 | | | |
| | 1st P. T. | . . . | 15 54 18 |
| | 2nd P. T. | 15 59 44 | 15 59 51 |
| | P. P. | 16 04 13 | 16 04 13 |
| | Max. | 17 00 | 17 00 |
| | End | 18 00 | 18 10 |
| Epicentre 3,800 km. | | | |
| | Inset | 22 09 08 | 22 09 10 |
| | Long Waves | . . . | 22 23 |
| | End | 23 15 | 23 20 |
| | 1st P. T. (?) | 23 46 | 23 48 |
| | 2nd P. T. (?) | 23 57 29 | 23 57 30 |
| | P. P. | 24 20 | 24 19 |
| | End | 25 15 | 25 21 |
| December 10. | A local shock. | | |
| | | 6 24 10 G.M.T. | 6 24 10 G.M.T. |

Duration 5 seconds. Windows rattled. People awakened. Noise resembled that of rapidly moving dray. Acceleration 31 milligals.

| December 22 | | | |
|---|---|---|---|
| | Long waves | . . . | 10 40 |
| | End | . . . | 10 49 |
| | Long waves | 13 52 | 13 52 |
| | Max. | . . . | 14 00 |
| | End | 14 11 | 14 20 |

1910

January 1. Yucatan earthquake not recorded. Clock-work under repairs.

| | | N–S Component | E–W Component |
|---|---|---|---|
| | | h m s | h m s |
| January 10 | | | |
| | Waves | 5 44 | 5 42 |
| | Long waves | 5 53·5 | 5 53·5 |
| | Max. | 6 00 | 6 00 |
| | End | 6 22 | 6 30 |
| January 12 | | | |
| | Waves | . . . | 2 28 |
| | Waves | 2 43·3 | 2 42·7 |
| | Max. | 2 45 | 2 45 |
| | End | 2 49 | 2 53 |
| January 22 | | | |
| | 1st P. T. | 8 55 35 | 8 55 35 |
| | 2nd P. T. | 9 01 30 | 9 01 29 |
| | P. P. | 9 04 | 9 04 |
| | Max. | 9 11·5 | 9 11·5 |
| | End | 10 24 | 10 52 |
| Epicentre 4,100 km. Quake north of Iceland. | | | |
| January 23 | | | |
| | 1st P. T. | 18 56 34 | 18 56 34 |
| | 2nd P. T. | 19 02 20 | 10 02 19 |
| | P. P. | 19 05 | 19 05 |
| | End | 20 04 | 20 10 |
| Epicentre 4,100 km. | | | |
| January 30 | | | |
| | 1st P. T. (?) | 16 21 34 | 16 21 30 |
| | P. P. | 16 23 26 | 16 23 34 |
| | Max. | 16 23 48 | 16 22 30 |
| | End | 16 35 | 16 36 |
| February 3 | | | |
| | Waves | . . . | 17 26 |
| | Long waves | . . . | 17 52·5 |
| | " " | . . . | 18 06 |
| | End | . . . | 18 25 |
| February 4 | | | |
| | Long waves (emerge) | 14 51 | 14 33 |
| | " " | 15 10 to 15 14 | 15 01 to 15 25 |
| | Max. | . . . | 15 10 |
| February 4 | | | |
| | Long waves | . . . | 19 42 |
| | End | . . . | 20 00 |

| February 12 | | N–W Component | E–W Component |
|---|---|---|---|
| | | h m s | h m s |
| | Emergence | 18 28 | 18 27 |
| | Inset | 18 33 00 | 18 33 00 |
| | " | 18 33 50 | 18 33 43 |
| | Long waves | 18 36·0 | 18 36·0 |
| | End | 19 00 | 19 20 |

O. K.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
February 4, 1910.

# NOTES FROM THE METEOROLOGICAL SERVICE

## EARTHQUAKE RECORDS BY MILNE'S SEISMOGRAPH

### TORONTO

R. F. STUPART, DIRECTOR.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 H = midnight.

| No. | Date 1909 | P.T Comm h | P.T Comm m | L.W. Comm. h | L.W. Comm. m | Max. h | Max. m | End. h | End. m | Max. Amp. mm. | Durat. h | Durat. m | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 883 | Dec. 9 | 16 | 1·5 | | | ? | | 18? | | 0·8? | 2 | 0·0 | Prolonged. Guam |
| 884 | " 9 | 22? | | | | | | | | | | | Ragged trace |
| 885 | " 9 | 23 | 55·0? | | | | | 25 | 0·0? | 0·15 | 1 | 5·0? | Extended small thickenings |
| | 1910 | | | | | | | | | | | | |
| 886 | Jan. 1 | 11 | 11·0 | 11 13·1<br>11 16·5 | | 11 | 18·0 | 13 | 34·0 | over 18 | 2 | 23·0 | Across paper. Yucatan |
| 887 | " 10 | 5 | 53·7 | | | | | 6 | 3·2 | 0·05 | 0 | 9·5 | |
| 888 | " 12 | 2 | 26·7 | | | 2 | 27·6 | 2 | 33·8 | 0·8 | 0 | 7·1 | |
| 889 | " 22 | 9 | 2·5 | 9 | 8·0 | 9 | 13·0 | 10 | 39·2 | 20 | 1 | 36·7 | Across the paper |
| 890 | " 23 | 18 | 59·5 | | | 19 | 26·5 | 20 | 23·0 | 0·3 | 1 | 23·5 | |

Vibration 14·8 seconds. 1 mm. 0″·64

### VICTORIA, B. C.

E. B. REED, SUPERINTENDENT.

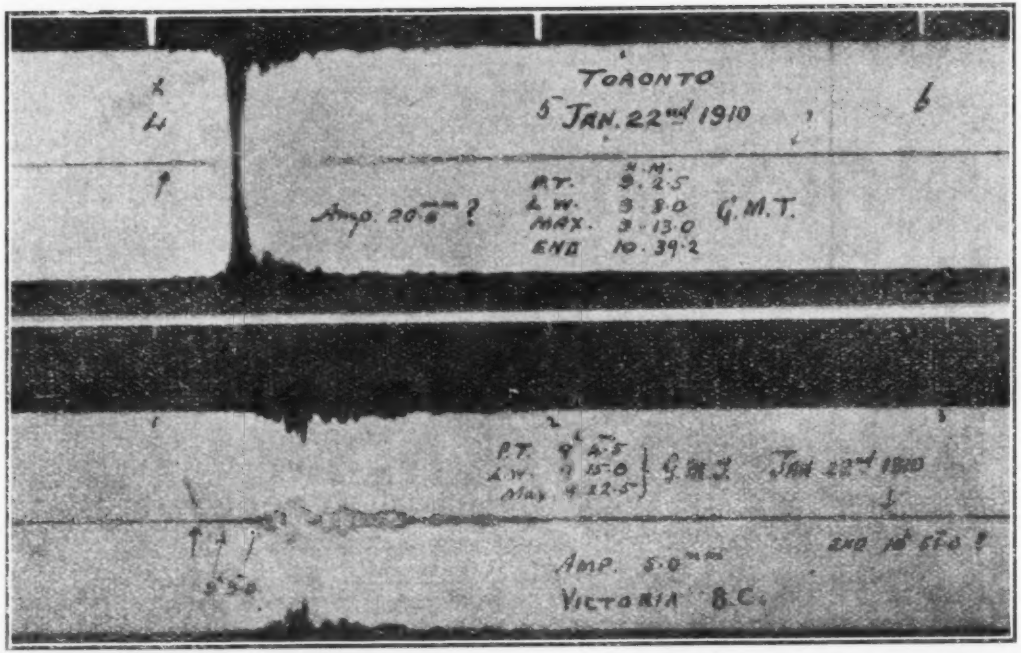
| No. | Date 1909 | P.T. Comm. h | P.T. Comm. m | L.W. Comm. | Max. h | Max. m | End h | End m | Max. Amp. mm. | Durat. h | Durat. m | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 910 | Dec. 4 | 1 | 34·9 | | | | 1 | 45·5 | 0·15 | 0 | 11·0 | Gradual beginning and |
| 911 | " 9 | 15 | 47·7 | | | | 17 | 36·7 | 0·6 | 1 | 49·0 | Guam: ending |
| 912 | " 9 | 22 | 2·2 | | | | 22 | 26·7 | 0·05 | 0 | 24·5 | |
| 913 | " 9 | 23 | 50·7 | | | | 24 | 44·0 | 0·1 | 0 | 53·3 | |
| | 1910 | | | | | | | | | | | |
| 914 | Jan. 1 | 11 | 9·9 | $V_2$ 11 12·0<br>11 19·4<br>B 11 30.0? | 11 | 35·4 | 13 | 10·0 | 5·1 | 2 | 0·1 | Caribbean Sea and Yucatan |
| 915 | " 10 | 5 | 52·5 | | | | 5 | 57·0 | 0·08 | 0 | 4·5 | Minute thickening |
| 916 | " 12 | 2 | 44·0 | | | | 2 | 47·5 | 0·1 | 0 | 3·5 | |
| 917 | " 22 | 9 | 4·5 | $V_2$ 9 9.0<br>9 15·0 | 9 | 22·5 | 10 | 51·0 | 5·0 | 1 | 46·5 | Medium disturbance |
| 918 | " 23 | 18 | 57·5 | | 19 | 10.5 | 19 | 52·0 | 1·0 | 0 | 54·5 | |

Vibration 15 seconds. 1 mm. = 0″·76.

ERRATUM — In last Seismological Tables of Victoria Series the Max. for 907 should read 6h 34·6m.

J. Y.

Records of the Earthquake of January 1, 1910, as shown on the Milne Seismometers at Toronto and Victoria.




Records of the Earthquake of January 22, 1910, as shown on the Milne Seismometers at Toronto and Victoria.

## Summary Report of the Weather in Canada

### December 1909

*Temperature*—The mean temperature of the month was decidedly below average over British Columbia and the Western Provinces, below to a somewhat lesser extent in western and southern Ontario and western Nova Scotia; and above the average throughout Quebec and over the larger portion of the Maritime Provinces. The largest negative departures were as much as 8° and 10° between Regina, Sask., and Medicine Hat, Alta., and the largest positive departures were about 8° in eastern Quebec. In Ontario, near Lake Erie, the negative departure was as much as 4° while in the Ottawa Valley there was a positive departure of from 1° to 2°.

*Precipitation*—The precipitation of the month exceeded the average from eastern Saskatchewan to eastern Ontario, also in the Gulf of St. Lawrence and eastern portions of the Maritime Provinces, while elsewhere in Canada, with local exceptions, the fall was deficient. The snowfall in southern Manitoba and south-eastern Saskatchewan was exceptionally heavy, being in some localities more than five times the normal quantity; in Ontario also, and especially in counties contiguous to Lake Huron and the Georgian Bay the snowfall was heavy.

### January, 1910

*Temperature*—The mean temperature of January was very considerably above the average throughout Canada east of the Rocky Mountains, the largest positive departures ranging between 6° and 10° in Saskatchewan, Quebec and New Brunswick, and the smallest ranging between 1° and 4° in western Ontario. In British Columbia the mean of the month was everywhere below the average by amounts ranging between 1° and 3°.

*Precipitation*—The amount of precipitation which was recorded during January exceeded the average in central and eastern Ontario, the Lower St. Lawrence Valley and eastern parts of the

## Temperatures for December, 1909 and January, 1910

| Station | December | | January | |
|---|---|---|---|---|
| | Highest | Lowest | Highest | Lowest |
| *Yukon* | | | | |
| Dawson | 12 | -45 | 24 | -54 |
| *British Columbia* | | | | |
| Atlin | 42 | -34 | 34 | -20 |
| Agassiz | 47 | 14 | 56 | 22 |
| Barkerville | 34 | -20 | 34 | -20 |
| Kamloops | 40 | 0 | 50 | 4 |
| New Westminster | 48 | 12 | 46 | 12 |
| Port Simpson | 42 | 14 | 42 | 14 |
| Vancouver | 48 | 17 | 50 | 15 |
| Victoria | 49 | 24 | 52 | 24 |
| *Western Provinces* | | | | |
| Battleford | 38 | 22 | 40 | -28 |
| Broadview | | | | |
| Calgary | 50 | -23 | 50 | -16 |
| Carman | | | | |
| Edmonton | 43 | -30 | 44 | -18 |
| Medicine Hat | 43 | -18 | 50 | - 8 |
| Minnedosa | 39 | -39 | 32 | -36 |
| Moosejaw | 35 | -22 | 39 | -29 |
| Oak Bank | 23 | -32 | 28 | -37 |
| Portage la Prairie | 26 | -32 | | |
| Prince Albert | 34 | -26 | 30 | -44 |
| Qu'Appelle | 34 | -30 | 36 | -40 |
| Regina | 43 | -29 | | |
| Swift Current | 40 | -22 | 48 | -18 |
| Winnipeg | 36 | -34 | 32 | -36 |
| *Ontario* | | | | |
| Agincourt | 46 | -9 | 40 | -10 |
| Aurora | 44 | -8 | 39 | -13 |
| Bancroft | 42 | -14 | 40 | -27 |
| Barrie | | | | |
| Beatrice | 40 | -9 | 38 | -23 |
| Birnam | 52 | 5 | 40 | 1 |
| Bloomfield | 44 | -10 | 42 | 2 |
| Brantford | 47 | -7 | 42 | -3 |
| Bruce Mines | 48 | -19 | 37 | -26 |
| Chatham | 59 | -2 | 42 | 3 |
| Clinton | 47 | -10 | 37 | -4 |
| Cottam | 56 | -9 | 43 | -2 |
| Cockburn Island | 46 | -3 | 37 | -11 |
| East Toronto | 49 | -10 | 39 | -11 |
| Gravenhurst | 41 | 7 | | |
| Haliburton | 40 | -5 | 39 | -20 |
| Hamilton | 41 | -4 | | |
| Huntsville | 45 | -8 | 38 | -21 |
| Kenora | 35 | -27 | 23 | -32 |
| Kinmount | 40 | -29 | 35 | -31 |
| Kingston | 45 | 6 | 46 | -11 |
| Lakefield | 44 | -10 | 40 | -16 |
| London | 51 | 0 | | |
| Lucknow | 47 | -14 | 38 | -10 |
| Madoc | 39 | -10 | 42 | -14 |
| Meaford | 47 | 5 | 43 | -1 |
| Midland | 52 | -7 | 40 | -15 |
| North Gower | | -10 | | |
| Otonabee | 40 | -5 | | |
| Ottawa | 35 | -10 | 45 | -18 |
| Owen Sound | 48 | 2 | 43 | -2 |
| Paris | 47 | -6 | 39 | -1 |
| Parry Sound | 42 | -14 | 40 | -21 |
| Peterboro' | 42 | -12 | 40 | -15 |
| Point Clark | | | | |
| Port Arthur | 43 | -9 | 35 | -22 |
| Port Burwell | 51 | -1 | 39 | -4 |
| Port Dover | 44 | -5 | 39 | -11 |
| Port Hope | 54 | -8 | 52 | -13 |
| Port Stanley | 51 | -1 | 39 | -8 |
| Ronville | 40 | -8 | 38 | -28 |
| Sarnia | 52 | 2 | 38 | 2 |
| Southampton | 48 | 1 | 41 | -3 |
| Stonecliffe | 44 | -16 | 40 | -25 |
| Stony Creek | 44 | -5 | 44 | 0 |
| Stratford | 46 | -13 | | |
| Toronto | 45 | -5 | 41 | -7 |
| Uxbridge | 43 | -12 | 39 | -17 |
| Wallaceburg | 55 | -2 | 40 | 6 |
| Welland | 52 | -2 | 42 | 1 |
| White River | 53 | -34 | 32 | -34 |
| *Quebec* | | | | |
| Brome | 37 | -14 | 52 | -26 |
| Father Point | 37 | 2 | 49 | -7 |
| Montreal | 37 | -2 | 47 | -15 |
| Quebec | 40 | -13 | 47 | -21 |
| Sherbrooke | 39 | -16 | 50 | -23 |
| *Maritime Provinces* | | | | |
| Charlottetown | 44 | 4 | 44 | 0 |
| Chatham | 41 | -8 | 52 | -12 |
| Dalhousie | 44 | -3 | 45 | -10 |
| Fredericton | 43 | -15 | 55 | -20 |
| Halifax | 46 | 2 | 51 | -14 |
| Moncton | 41 | -16 | 50 | -12 |
| St. John | 42 | 4 | 52 | -8 |
| St. Stephen | 43 | -14 | 49 | -12 |
| Summerside | | | | |
| Sussex | 46 | -20 | 55 | -14 |
| Sydney | 44 | 14 | 50 | 10 |
| Yarmouth | 46 | 12 | 52 | 4 |

Maritime Provinces ; elsewhere in Canada the normal value was not reached, except very locally in the neighborhood of Battleford, Sask., in the Cariboo district and generally in the lower levels of British Columbia, and also in the extreme southwest counties of Ontario.

## MAGNETIC OBSERVATIONS

The magnetic curves at Agincourt for the months of December and January did not show any important disturbances. The largest movement in December took place on the 13th and in January between the 23rd and the 25th. Small disturbances of an undulatory character occurred in December on the 1st, 13th, 14th, 17th and 21st, and in January on 17th, 22nd, and 23rd to 26th ; the remaining days of these months being remarkably quiet.

The accompanying table gives the magnetic data for the two months.

Horizontal Force

| | Monthly Mean | Mean Daily Range | Max. | Date | Min. | Date | Monthly Range |
|---|---|---|---|---|---|---|---|
| 1909 Dec. | ·16282 | 25 γ | ·16311 | 31 | ·16197 | 13 | 113 γ |
| 1910 Jan. | ·16286 | 27 γ | ·16339 | 22 | ·16191 | 23 | 139 γ |

Declination

| | Monthy Mean | Mean Daily Range | Max. | Date | Min. | Date | Monthly Range |
|---|---|---|---|---|---|---|---|
| | ° ′ | ′ | ° ′ | | ° ′ | | ′ |
| 1909 Dec. | 6 1·7 | 7·0 | 6 17·9 | 13 | 5 42·4 | 13 | 35·5 |
| 1910 Jan. | 6 1·7 | 5·1 | 6 16·6 | 25 | 5 30·2 | 23 | 46·4 |

# BOOK REVIEWS

*The Life of the Universe: as conceived by man from the earliest ages to the present time.* By SVANTE ARRHENIUS. London and New York: Harper and Brothers; 1909. *xvi.* + *xii.* + 268 pp.

In two modest little volumes the learned and original Director of the Physico-Chemical Nobel Institute of Stockholm has given a concise but comprehensive and stimulating account of the evolution of ideas with respect to the arrangement and constitution of the universe. The earlier chapters are devoted to the statement and correlation of the theories and speculations of the Chaldæans, the Greeks, the Hindus, the Chinese and the Scandinavians, and the reader may gain from them a fair view of the methods and extent of the astronomical science of the ancients. In his consideration of the work of the founders of modern astronomy the estimates of the author, it goes without saying, are always just; the nature of the subject, however, allows him to give a certain prominence to the speculations of Swedenborg, Descartes, Buffon and Kant. The concluding chapters, on "The Energy Conception in Cosmogony," and "The Conception of Infinity in Cosmogony," are, perhaps, the most interesting, dealing as they do with the outstanding problems of physical astronomy, and treating of such matters as radiation pressure and the function of radio-active substances.

The book is a very readable one, the work of the translator being well done. It will doubtless lead many of its readers to a study of the author's remarkable "Worlds in the Making."

*δ.*

## ASTRONOMICAL NOTES

THE BRIGHTNESS OF THE SATELLITES OF MARS—The statement is made in some recent text books on astronomy that *Phobos* and *Deimos*, the two small satellites of *Mars*, can be seen only with very large telescopes and *then only by screening the light from the planet*. A series of measures of these two satellites was made by me in September and October of the present year, and this gave me the opportunity to confirm my impression of the error of the statement. A large telescope is indeed required to show these tiny bodies. and they can be seen only when *Mars* is comparatively near opposition, but under good conditions it is unnecessary to protect the eye from the light of the planet. *Phobos*, the inner satellite, is very decidedly the brighter of the two, and can be seen with the 36-inch, in the full light of *Mars* when less than 3″ from the planet's limb, *Deimos* is fainter, and is a difficult object in the planet's light when 10″ from the limb. At distances greater than these limits both satellites are readily visible without screening the light from *Mars*, when the seeing is good. My estimates make *Phobos* fully six times as bright as *Deimos* when at the same distance from the planet ; that is, about two stellar magnitudes brighter.—R. G. AITKEN, in *Publications of the Astronomical Society of the Pacific*, No. 129.

IN *Smithsonian's Publication*, No. 1898, C. G. Abbot, Director of the Smithsonian Astrophysical Observatory, in closing a discussion on the work of Professor Hale, at the Mount Wilson Solar Observatory, in regard to "Solar Vortices and Magnetism of Sun Spots," says : — "Let us sum up the principal parts of

Mr. Hale's experimental evidence: (1) That some spectrum lines which are single in the ordinary solar spectrum become double in sun spots; (2) that these double lines are found to be circularly polarized in opposite directions; (3) that, as shown by Zeeman, this is a characteristic of spectrum lines produced in a powerful magnetic field and observed along the magnetic lines of force; (4) that the different doublets in the spots in most cases have almost exactly the same relative separations as have the corresponding lines when observed in the laboratory in a magnetic field; (5) that lines found double in spots near the sun's limb are also found double when observed in the laboratory at right angles to a magnetic field; (6) that, as shown by Rowland, electric charges in revolution produce a magnetic field; (7) that, as shown by Thomson, it is probable that electrically charged bodies or ions are numerous in the sun; (8) that the spectroheliograph has shown immense spiral configurations suggesting vortices in the higher solar layers and that these vortices are unmistakably connected with sun spots; (9) that the vortices are some right handed and others left handed; (10) that in sun spots surrounded by right-handed vortices the polarization of the components of the spectrum doublets is always found opposite to that for sun spots with left-handed vortices. In view of all this it must be admitted that the existence of magnetic fields in the neighborhood of sun spots is beyond reasonable question, and Mr. Hale's explanations of them as due to the revolution of electrical charges in vortices have strong support. At the same time it must be kept in mind that the vortical motions are inferred rather than demonstrated, and inferred only for high levels, presumably above the levels of sun spots. Furthermore, spectra of spots near the sun's limb do not reveal evidence of motion such as would be expected if vortices exist in the spots themselves. Further evidence must therefore be awaited before fully accepting the vortex theory of the production of the magnetic fields which Mr. Hale has discovered.

A possible application to terrestrial affairs of this new discovery of magnetism in sun spots springs at once into mind, but

according to Mr. Hale's view the evidence at present is opposed to the conclusion that the magnetic fields found in sun spots can produce appreciable effects on the earth. Nevertheless, it will be almost a matter of regret if further study shall not indicate that the magnetic sun spot fields are competent to produce the disturbances of terrestrial magnetism which for many years have been known to be intimately related to the prevalence of sun spots."

PROFESSOR KAPTEYN, Director of the Observatory of the University of Groningon, in summing up the results of "Recent Researches in the Structure of the Universe," *Smithsonian Institution Publication*, No. 1897, remarks:—"Is the universe really absolutely transparent? There are reasons which make this seem very doubtful. A couple of years ago I obtained some evidence in the matter which shows that the absorption of light in space, if it exists to an appreciable amount, must at least be so small that over a distance of a hundred light years not more than a few per cent. of the light can be lost. To determine so small an amount to within a small fraction of its total value will be a difficult task indeed. Still we can even now see definite ways, which, given the necessary data for very faint stars and nebulæ, will probably enable us to overcome this last difficulty.

What is the real structure of the stellar world? If we see so many stars in the field, with the telescope directed to the Milky Way, is it because they are really more closely crowded there, as Struve thinks, or is the view of the older Herschel correct, who imagined that the greater richness is simply a consequence of the fact that we are looking in deeper layers of stars; that our universe is more extensive in the Milky Way than it is in other directions?

Imagine that we could actually travel through space. For instance, imagine that first we travel in the direction of the constellation Cassiopeia. If we travel with the velocity of light, not so very many years would pass before we get near to some star. Proceeding on our journey for many, many more years, always straight on, we will pass more stars by and by. How will these

stars look thus viewed from a moderate distance—say, from a distance as that of sun?

In travelling on shall we find the stars in reality equally thickly or rather thinly crowded everywhere? Or shall we find that after a certain time, which may be many centuries, they begin to thin out as a first warning of an approaching limit of the system? Is there really such a limit, which, once passed, leads us into abysses of void space?

We may condense these questions in this single query: How does the crowding of the stars, or the star density, that is the number of stars in any determined volume (let us say in a cubic light century) vary with the distance from our solar system?

Methods are not wanting which, given the necessary observational data obtainable in a moderate time, may lead us to a true, be it provisionally still not very detailed, insight into the real distribution of stars in space.

I think this time need not exceed some fifteen years. They to whom such a time may still seem somewhat long may be reminded of the fact that that time will be elapsed, that we shall have finished our work, before any but a very few of our nearest neighbors in space can be aware of the fact that we have begun.

A DISPATCH, dated February 23, 1910, from Harvard College Observatory, stating that a comet was observed by Pidoux, at Geneva, Switzerland, February $20^{d}{\cdot}2815$, Greenwich Mean Time, in R. A. $0^{h}\ 46^{m}\ 22^{s}{\cdot}1$, Dec. $+\ 7^{\circ}\ 50'\ 41''$.

NOTE:—The position of Halley's Comet at the time of the above observation, according to the corrected ephemeris of Crommelin, *A. N.* 183, p. 169, is R. A. $0^{h}\ 41^{m}\ 29^{s}$, Dec. $+\ 7^{\circ}\ 55'$.

HALLEY'S COMET IN 1835.—Dr. Wm. G. Todd, writing from Chicago, describes Halley's comet as seen by him when 14 years of age at its last apparition. When first seen, it appeared in the western sky, just after sunset, almost horizontal with the tail directed towards the south. It could be plainly seen directly after sunset every day for perhaps a month or more, before the

stars became visible. Its tail was broad, but not to be compared in length with that of the comet of 1843. (*Popular Astronomy*, February).

Observation of Faint Stars.—For observations of the companion of Procyon, Professor Barnard places a hexagonal diaphragm over his object-glass. If the aperture be of this shape, the diffused light will appear in the field as collected into six thin rays meeting in the bright star. Between these rays the sky will be dark, and faint objects will be seen. If the bright star be a planet, the thin rays become bars of light with a thickness equal to the planet's diameter. The disc of Jupiter is large in the 40-in. telescope, and the method is therefore less useful in that case. (*A. N.*, No. 4345.)

Star Swarms.—Professor H. H. Turner, in the January number of the *Fortnightly Review* (p. 140), gives an account of Migrating Stars. Professor Boss's work, showing that a number of stars in Tauras are moving in parallel lines is explained and illustrated. The cluster, which is now 120 light-years from us, occupies on the celestial globe an area comparable with that occupied by India on the terrestrial. In 65 million years this area will be no larger than that occupied by Anglesea. (*B.A.A.*, January, 1910).

Mirrors.—M. A. Perot recommends, as a protection for the silvering of mirrors, an extremely thin layer of transparent celluloid. (*Comptes Rendus*, CXLIX., 725). J.R.C.

# PREDICTIONS FOR MARCH AND APRIL

PREPARED BY R. M. STEWART

## The Constellations in March and April*

The brilliant constellations of the winter months are now sinking towards the west, and soon we will have in their place the somewhat less resplendent, though equally interesting, summer skies. Orion and Sirius are already low in the south-west; above Sirius, nearly half-way from the horizon to the zenith, is Procyon; still higher, and almost directly above Orion, are the twin stars Castor and Pollux. Somewhat to the north of west, half-way up to the zenith, is Capella, the most northerly of the first magnitude stars, which in latitude 45 never sets, but at its lowest merely grazes the northern horizon. Beneath it are the Pleiades, while a little to the west of the northern horizon is the familiar wide W of Cassiopeia, the Lady in her Chair. About half-way between the Pleiades and Orion is the first magnitude star Aldebaran, and a few degrees above the latter the planet Mars. About one-third of the way from the Pleiades towards Cassiopeia is Algol, "The Demon of the slowly winking Eye," and near it a fourth magnitude star which affords a good comparison for its variations in brightness.

Just east of the meridian, and somewhat to the south of the zenith, is the zodiac constellation Leo, marked by a group of six stars arranged in the form of a sickle; the brightest star in the constellation, Regulus, is at the extremity of the handle. The ancients divided the zodiac into twelve signs or constellations,

*As they appear at 9 p.m. on April 1; they may be located on other dates by remembering that at a month earlier they are in the same positions (except the planets) at 11 p.m., and a month later at 7 p.m.

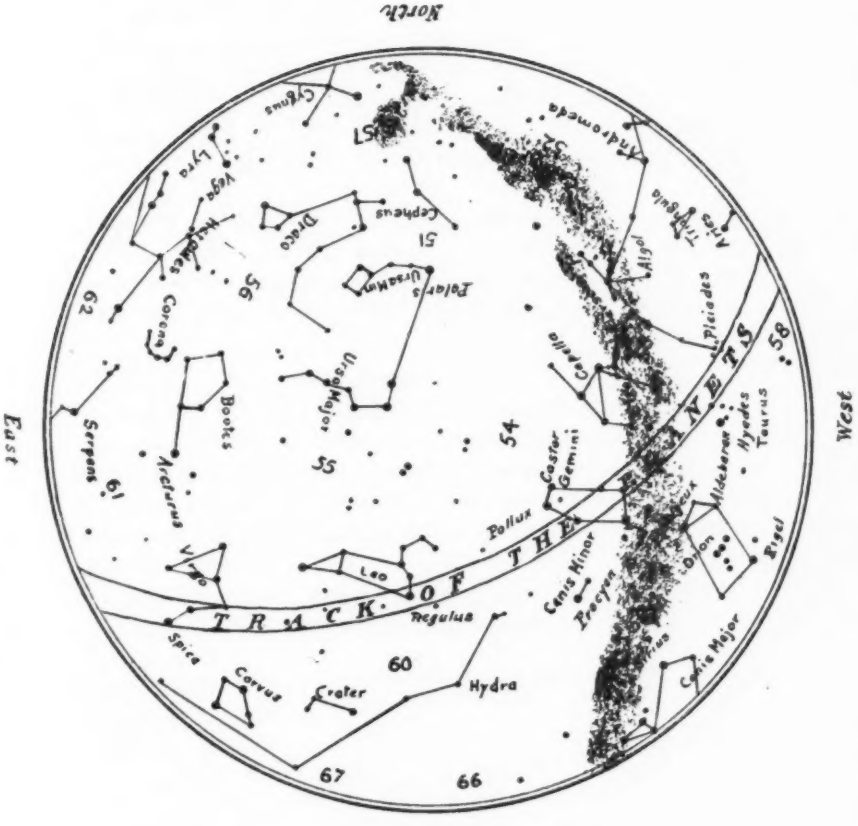
one corresponding to each month of the year ; it is supposed that the beginning of spring, that is, the vernal equinox, was marked by the entrance of the sun into the first sign Aries ; in course of time, however, through the precession of the earth's axis, the vernal equinox, or first point of Aries, as it still continues to be called, has retrograded through nearly a whole constellation, so that the *sign* Aries now practically coincides with the *constellation* Pisces. Hence it is, for example, that Leo, which is the fifth in order of the zodiacal signs, is yet the sixth constellation occupied by the sun since the vernal equinox.

Turning again to the north, Polaris is now, as always, halfway from the horizon to the zenith ; Ursa Minor, more familiarly known as the Little Dipper, extends in a curve to the eastward, while higher up, and somewhat to the east of the meridian, is Ursa Major, the Great Bear, whose more conspicuous stars form the group known as the Great Dipper. The two most westerly stars of the Dipper, known as the Pointers, furnish the simplest method of at any time locating the meridian by finding the pole star, as the line joining them, when produced, passes very nearly through the latter. To astronomers the Dipper is of peculiar interest in that five of the seven principal stars composing it have been demonstrated to be moving parallel to each other with practically the same velocity, and hence, though separated from each other by almost inconceivable distances, are probably members of one physical family travelling in company. Within only the last few months* it has been shown to be possible, if not probable, that a number of stars in different parts of the heavens, Sirius among the number, are also members of this vast family of suns.

## Mercury

Mercury is a morning star until April 5, when it passes to the east of the sun. By the end of April it has very nearly reached its greatest elongation east, and will then be more favor-

* "On New Members of the System of the Stars $\zeta$, $\gamma$, $\delta$, $\epsilon$, $\zeta$, *Ursæ Majoris*," by Ejnar Hertzsprung. *Astrophysical Journal*, September, 1909.




THE CONSTELLATIONS ON APRIL 1, AT 9 P.M.

ably situated for observation than at most elongations, as it will remain above the horizon for nearly two hours after the sun has set.

### Venus

Venus, which passed to the west of the sun on February 11, is now a morning star. It attains its greatest brilliancy on March 19, at which time it rises about two hours before the sun. It is stationary among the stars on March 3, but does not reach its greatest distance west of the sun until April 23, when it may be seen in the eastern sky for over three hours before sunrise.

### Mars

Mars continues to get fainter as its distance from the earth increases. During March and April it continues as an evening star, constantly moving to the eastward among the constellations, though being slowly overtaken by the sun. It is in conjunction with the moon on March 15 and April 13.

### Jupiter

During these months Jupiter is very favorably situated for observation, and with its system of moons will well repay examination in a telescope. Its motion among the stars is small, being about 6° to the west and 2° to the north. During the first week in April it passes within a degree of the third magnitude star *γ Virginis*, north-west of Spica. At the beginning of March it rises at about half past eight in the evening, but by the end of April is well up in the eastern sky at sunset.

### Meridian Passage of the Principal Planets in March and April

LOCAL MEAN TIME

| | For March 15 | | For April 15 |
|---|---|---|---|
| Mercury | 11.05 A.M. | Capricornus, Aquarius, Pisces, Aries, Taurus | 12.40 P.M. |
| Venus | 9.43 A.M. | Aquarius, Pisces | 9.09 A.M. |
| Mars | 4.24 P.M. | Aries, Taurus, Gemini | 3.44 P.M. |
| Jupiter | 1.17 A.M. | Virgo | 10.57 P.M. |
| Saturn | 1.56 P.M. | Pisces, Aries | 12.08 P.M. |
| Uranus | 8.17 A.M. | Sagittarius | 6.18 A.M. |
| Neptune | 7.41 P.M. | Gemini | 5.39 P.M. |

SOME INTERESTING DOUBLES VISIBLE IN SMALL TELESCOPES

11 *Cancri*. R. A. $8^h\ 3{\cdot}3^m$; Dec. 27° 45′; magnitudes 7, 5; distance 3″; pale yellow and lilac.

$\zeta$ *Cancri*. R. A. $8^h\ 7{\cdot}1^m$; Dec. 17° 55′; magnitudes 5·0, 5·7, 5·5; distances 1″, 5″. The close pair is a binary of period 59·1 years; the third star revolves about this pair in the opposite direction in from 600 to 700 years; from irregularities in its motion it has been found to be also a binary with a period of 17·6 years. This quadruple system is thus one of the most interesting of multiple stars.

$\varphi^1$ *Cancri*. R. A. $8^h\ 21{\cdot}3^m$; Dec. 27° 14′; magnitudes 6, 6·5; distance 4″·6.

$\sigma^1$ *Cancri*. R. A. $8^h\ 48{\cdot}8^m$; Dec. 30° 55′; magnitudes 5·9, 6·4; distance 1″·5; both stars yellow; a good telescopic test; a companion of 10·5 magnitude at a distance of about 70″.

$\varepsilon$ *Hydræ*. R. A. $8^h\ 42{\cdot}0^m$; Dec. 6° 45′; magnitudes 3·8, 7·8; distance 3″·2; colors yellow and blue. A binary system with a period of about 700 years. The brighter is itself a rapid binary, the components being nearly equal and extremely close.

$\gamma$ *Leonis*. R. A. $10^h\ 15{\cdot}0^m$; Dec. 20° 18′; magnitudes 2, 3·5; distance 2″·5; orange and reddish green; a binary with a period of 407 years.

35 *Sextantis*. R. A. $10^h\ 38{\cdot}6^m$; Dec. 5° 13′; magnitudes 6·1, 7·2; distance 6″·7; colors yellow and blue.

$\xi$ *Ursæ Majoris*. R. A, $11^h\ 13{\cdot}4^m$; Dec. 32° 3′; magnitudes 4, 4·9; distance 2″; this was the first binary whose orbit was calculated; its period is 60·8 years.

$\iota$ *Leonis*. R. A. $11^h\ 19{\cdot}2^m$; Dec. 11° 1′; magnitudes 3·9, 7·1; distance 2″·6; colors yellow and blue.

65 *Ursæ Majoris*. R. A. $11^h\ 50{\cdot}4$; Dec. 46° 59′; magnitudes 6, 8, 7; distances 4″, 63″; colors white, blue, white; all three stars probably physically connected.

$\zeta$ *Ursæ Majoris* (Mizar), R. A. $13^h\ 20{\cdot}3^m$; Dec. 55° 24′; magnitudes 2·1, 4·2; distance 14″·4. The brighter star is a spectroscopic double, with a mass about 40 times that of the sun. It is the middle star of the handle of the Great Dipper, and with

the adjacent fifth magnitude star Alcor forms a pair visible to the naked eye ; the latter is supposed to be also physically associated with the group.

### Clusters and Nebulæ

*H.*VI. 37. R. A. $7^h\ 55{\cdot}7^m$ ; Dec. $-10°\ 23'$. A broad starry cloud containing stars from the tenth magnitude down to the very faintest ; shown best with fairly low powers ; many fine fields in the vicinity.

*H.*VII. 11. R. A. $8^h\ 6{\cdot}5^m$ ; Dec. $-12°\ 34'$. A large, loose cluster of stars, chiefly of about the tenth magnitude.

*M.* 44. R. A. $8^h\ 34{\cdot}9^m$; Dec. $20°\ 18'$. The star-cluster known as Præsepe (The Beehive). Visible to the naked eye on clear nights when the moon is absent. It lies to the south-east of Pollux, forming a nearly right-angled triangle with the latter star and Procyon, and being about one-third nearer Pollux. It is perhaps best seen with a small telescope or opera-glass.

*M.* 67. R. A. $8^h\ 46{\cdot}4^m$; Dec. $12°\ 9'$. A pretty cluster containing about 200 stars from the tenth to the fifteenth magnitude.

*M.* 81 and 82. R. A. $9^h\ 48^m$ ; Dec. $69°\ 30'$. Two fine nebulæ, separated by half a degree. The preceding one is a bright oval with a central condensation, and several small stars in the neighborhood. The other is a long narrow object, somewhat paler.

*H.*IV. 27. R. A. $10^h\ 20{\cdot}5^m$ ; Dec. $-18°\ 11'$. A planetary nebula of about the apparent size of Jupiter ; slightly elliptical ; bears magnifying well.

*M.* 97. R. A. $11^h\ 9{\cdot}6^m$ ; Dec. $55°\ 31'$. The Owl Nebula. In ordinary telescopes it presents the appearance of a faintly illuminated disc ; in more powerful instruments, however, it is found to be of a complicated spiral structure. It derives its name from two large perforations thought to resemble the eyes of an owl.

*H.*I. 223. R. A. $11^h\ 54{\cdot}8^m$ ; Dec. $51°\ 28'$. A nebula in the form of a slender sharp-pointed ray, with a tenth magnitude star in the centre.

## ECLIPSES AND TRANSITS OF THE SATELLITES OF JUPITER

E = eclipse, O = occultation, T = transit, S = shadow, D = disappearance, R = re-appearance, I = ingress, e = egress.

Eastern Standard Time; hours numbering from midnight.

### MARCH

| d | h | m | | | d | h | m | | | d | h | m | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 39 | II. | ED | 10 | 2 | 29 | I. | OR | 19 | 19 | 53 | I. | Te |
| | 3 | 26 | I. | ED | | 2 | 34 | II. | Se | 20 | 19 | 47 | III. | TI |
| 2 | 0 | 37 | I. | SI | | 3 | 29 | II. | Te | | 21 | 09 | III. | Se |
| | 1 | 18 | I. | TI | | 4 | 56 | III. | OR | | 21 | 53 | III. | Te |
| | 2 | 53 | I. | Se | | 21 | 00 | I. | SI | 24 | 3 | 35 | I. | ED |
| | 3 | 31 | I. | Te | | 21 | 29 | I. | TI | | 4 | 58 | II. | SI |
| | 21 | 17 | II. | SI | | 23 | 15 | I. | Se | | 5 | 19 | II. | TI |
| | 21 | 54 | I. | ED | | 25 | 42 | I. | Te | 25 | 0 | 48 | I. | SI |
| | 22 | 36 | II. | TI | 11 | 20 | 55 | I. | OR | | 0 | 57 | I. | TI |
| | 23 | 11 | III. | ER | | 22 | 07 | II. | OR | | 3 | 03 | I. | Se |
| | 23 | 31 | III. | OD | 16 | 4 | 25 | I. | SI | | 3 | 11 | I. | Te |
| 3 | 0 | 01 | II. | Se | | 4 | 47 | I. | TI | | 22 | 03 | I. | ED |
| | 0 | 44 | I. | OR | 17 | 1 | 41 | I. | ED | | 23 | 46 | II. | ED |
| | 1 | 13 | II. | Te | | 2 | 24 | II. | SI | 26 | 0 | 22 | I. | OR |
| | 1 | 35 | III. | OR | | 3 | 06 | II. | TI | | 2 | 39 | II. | OR |
| | 21 | 21 | I. | Se | | 4 | 13 | I. | OR | | 19 | 16 | I. | SI |
| | 21 | 57 | I. | Te | | 4 | 41 | III. | ED | | 19 | 23 | I. | TI |
| 8 | 5 | 16 | II. | ED | | 5 | 07 | II. | Se | | 21 | 31 | I. | Se |
| | 5 | 19 | I. | ED | | 5 | 43 | II. | Te | | 21 | 37 | I. | Te |
| 9 | 2 | 31 | I. | SI | | 22 | 54 | I. | SI | 27 | 20 | 57 | II. | Se |
| | 3 | 03 | I. | TI | | 23 | 13 | I. | TI | | 21 | 04 | II. | Te |
| | 4 | 46 | I. | Se | 18 | 1 | 09 | I. | Se | | 22 | 33 | III. | SI |
| | 5 | 16 | I. | Te | | 1 | 28 | I. | Te | | 23 | 03 | III. | TI |
| | 23 | 48 | I. | ED | | 20 | 09 | I. | ED | 28 | 1 | 06 | III. | Se |
| | 23 | 51 | II. | SI | | 21 | 10 | II. | ED | | 1 | 12 | III. | Te |
| 10 | 0 | 43 | III. | ED | | 22 | 38 | I. | OR | 31 | 5 | 26 | I. | OD |
| | 0 | 51 | II. | TI | 19 | 0 | 23 | II. | OR | | | | | |

### APRIL

| d | h | m | | | d | h | m | | | d | h | m | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 41 | I. | TI | 9 | 4 | 00 | I. | ER | 18 | 3 | 46 | II. | Te |
| | 2 | 42 | I. | SI | | 4 | 32 | II. | OD | | 4 | 38 | II. | Se |
| | 4 | 55 | I. | Te | | 22 | 52 | I. | TI | | 19 | 28 | I. | SI |
| | 4 | 57 | I. | Se | | 23 | 05 | I. | SI | | 21 | 16 | I. | Te |
| | 23 | 52 | I. | OD | 10 | 1 | 05 | I. | Te | | 21 | 43 | I. | Se |
| 2 | 2 | 07 | I. | ER | | 1 | 20 | I. | Se | 19 | 19 | 58 | II. | OD |
| | 2 | 17 | II. | OD | | 20 | 02 | I. | OD | | 23 | 34 | II. | ER |
| | 5 | 02 | II. | ER | | 22 | 29 | I. | ER | 21 | 22 | 29 | III. | OD |
| | 21 | 07 | I. | TI | | 22 | 53 | II. | TI | 22 | 2 | 51 | III. | ER |
| | 21 | 11 | I. | SI | | 23 | 22 | II. | SI | 24 | 2 | 21 | I. | TI |
| | 23 | 21 | I. | Te | 11 | 1 | 32 | II. | Te | | 2 | 54 | I. | SI |
| | 23 | 26 | I. | Se | | 2 | 05 | II. | Se | | 23 | 30 | I. | OD |
| 3 | 20 | 35 | I. | ER | 12 | 20 | 57 | II. | ER | 25 | 2 | 17 | I. | ER |
| | 20 | 39 | II. | TI | 14 | 19 | 11 | III. | OD | | 3 | 23 | II. | TI |
| | 20 | 48 | II. | SI | | 22 | 53 | III. | ER | | 20 | 48 | I. | TI |
| | 23 | 18 | II. | Te | 16 | 3 | 20 | I. | OD | | 21 | 23 | I. | SI |
| | 23 | 31 | II. | Se | 17 | 0 | 36 | I. | TI | | 23 | 02 | I. | Te |
| 4 | 2 | 18 | III. | TI | | 1 | 00 | I. | SI | | 23 | 38 | I. | Se |
| | 2 | 31 | III. | SI | | 2 | 50 | I. | Te | 26 | 20 | 45 | I. | ER |
| | 4 | 29 | III. | Te | | 3 | 15 | I. | Se | | 22 | 16 | II. | OD |
| | 5 | 04 | III. | Se | | 21 | 46 | I. | OD | 27 | 2 | 10 | II. | ER |
| 8 | 4 | 25 | I. | TI | 18 | 0 | 23 | I. | ER | 28 | 20 | 30 | II. | Se |
| | 4 | 37 | I. | SI | | 1 | 07 | II. | TI | 29 | 1 | 49 | III. | OD |
| 9 | 1 | 36 | I. | OD | | 1 | 56 | II. | SI | | | | | |

## At Greenwich Mean Noon

| Date 1910 | Day of Year | The Sun's Right Ascension | The Sun's Declination | Equation of Time Sub't from Mean Time | Sidereal Time |
|---|---|---|---|---|---|
| | | h m s | ° ′ ″ | m s | h m s |
| Tues. 1 | 60 | 22 46 16·16 | S. 7 48 38·0 | 12 37·69 | 22 33 38·47 |
| Fri. 4 | 63 | 22 57 29·02 | 6 39 58·9 | 12 0·90 | 22 45 28·13 |
| Mon. 7 | 66 | 23 8 37·86 | 5 30 28·6 | 11 20·07 | 22 57 17·79 |
| Thur. 10 | 69 | 23 19 43·16 | 4 20 17·4 | 10 35·71 | 23 9 7·45 |
| Sun. 13 | 72 | 23 30 45·37 | 3 9 36·2 | 9 48·25 | 23 20 57·11 |
| Wed. 16 | 75 | 23 41 44·90 | 1 58 36·2 | 8 58·13 | 23 32 46·77 |
| Sat. 19 | 78 | 23 52 42·24 | S. 0 47 28·0 | 8 5·81 | 23 44 36·43 |
| Tues. 22 | 81 | 0 3 37·95 | N. 0 23 38·4 | 7 11·86 | 23 56 26·09 |
| Fri. 25 | 84 | 0 14 32·66 | 1 34 33·5 | 6 16·91 | 0 8 15·75 |
| Mon. 28 | 87 | 0 25 26·96 | 2 45 8·3 | 5 21·55 | 0 20 5·41 |
| Thur. 31 | 90 | 0 36 21·49 | N. 3 55 13·7 | 4 26·43 | 0 31 55·07 |

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena

| | | | Minima of Algol | Configuration of Jupiter's Satellites at 1h. |
|---|---|---|---|---|
| | | | h m | |
| Tues. | 1 | | 2 29 | 3 4 1 2 ○ |
| Wed. | 2 | | | 4 3 ○ 1 2 |
| Thur. | 3 | 0h ☿ in Aphelion; 19h ☿ Stationary. | 23 18 | 2 4 4 ○ 1 ● |
| ☾ Fri. | 4 | 2h 52·2m Last Quarter. | | 4 2 1 ○ 3 |
| Sat. | 5 | | | 4 ○ 2 1 3 |
| Sun. | 6 | | 20 07 | 4 1 ○ 3 2 |
| Mon. | 7 | 7h 39m ☌ ♅ ☾, ♅ 3′ 34′ N. | | 4 2 3 ○ 1 |
| Tues. | 8 | 16h 17m ☌ ☿ ☾, ☿ 11° 52′ N. | | 3 4 1 2 ○ |
| Wed. | 9 | 15h 31m ☌ ☿ ☾, ☿ 3° 14′ N. | 16 56 | 3 ○ 4 1 2 |
| Thur. | 10 | | | 2 4 ○ 4 ● ● |
| ● Fri. | 11 | 7h 12.4m New Moon. | | 2 1 ○ 3 4 |
| Sat. | 12 | 18·2h ☾ in Perigee. | 13 45 | ○ 2 1 3 4 |
| Sun. | 13 | 9h 45m ☌ ♄ ☾, ♄ 0° 58′ N. | | 1 ○ 2 3 4 |
| Mon. | 14 | | | 2 3 ○ 1 4 |
| Tues. | 15 | | 10 34 | 3 2 1 ○ 4 |
| Wed. | 16 | 2h 17m ☌ ♂ ☾, ♂ 1° 16′ N. | | 3 ○ 1 2 4 |
| ☽ Thur. | 17 | 22h 37·3m First Quarter. | | 3 1 ○ 2 4 |
| Fri. | 18 | | 7 22 | 2 4 2 4 ○ 3 |
| Sat. | 19 | 0h ☿ greatest brilliancy; 9h 20m ☌ ♆ ☾, ♆ 4° 21′ S. | | 4 ○ 2 1 3 |
| Sun. | 20 | | | 4 1 ○ 2 3 |
| Mon. | 21 | 7h ☉ enters Aries. Spring begins. | 4 11 | 4 2 3 ○ 1 |
| Tues. | 22 | | | 4 3 2 1 ○ |
| Wed. | 23 | 9h ☿ Greatest Heliocentric Lat. S. | | 4 3 ○ 1 2 |
| Thur. | 24 | | 1 00 | 4 3 1 ○ 2 |
| ○ Fri. | 25 | 15h 20·7m Full Moon. | | 2 4 2 4 ○ 3 |
| Sat. | 26 | 1h 21m ☌ ♃ ☾, ♃ 2° 31′ S. | 21 49 | ○ 1 4 3 ● |
| Sun. | 27 | | | 1 ○ 2 3 4 |
| Mon. | 28 | 6·2h ☾ in Apogee; 8h ♆ Stationary. | | 2 4 3 ○ 1 4 |
| Tues. | 29 | | 18 38 | 3 2 1 ○ 4 |
| Wed. | 30 | ♃ Greatest Hel. Lat. N. | | 3 ○ 1 2 4 |
| Thur. | 31 | 1h ☍ ♃ ☉. | | 3 1 ○ 2 4 |

Key to Symbols.—☌ Conjunction; ☍ Opposition; □ Quadrature; ☊ Ascending Node; ☋ Descending Node; ☉ Sun; ☿ Mercury; ♀ Venus; ⊕ Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; ♆ Neptune.

## At Greenwich Mean Noon

| Date 1910 | Day of Year | The Sun's Right Ascension | The Sun's Declination | Equation of Time Subt'd from / Added to Mean Time | Sidereal Time |
|---|---|---|---|---|---|
| | | h m s | ° ′ ″ | m s | h m s |
| Fri. 1 | 91 | 0 39 59·83 | N. 4 18 27·4 | 4 8·21 | 0 35 51·62 |
| Mon. 4 | 94 | 0 50 55·58 | 5 27 39·8 | 3 14·30 | 0 47 41·28 |
| Thur. 7 | 97 | 1 1 52·86 | 6 36 1·8 | 2 21·92 | 0 59 30·4 |
| Sun. 10 | 100 | 1 12 52·11 | 7 43 23·6 | 1 31·51 | 1 11 20·60 |
| Wed. 13 | 103 | 1 23 53·68 | 8 49 35·2 | 0 43·42 | 1 23 10·26 |
| Sat. 16 | 106 | 1 34 57·92 | 9 54 26·7 | 0 2·01 | 1 34 59·93 |
| Tues. 19 | 109 | 1 46 5·23 | 10 57 48·7 | 0 44·36 | 1 46 49·59 |
| Fri. 22 | 112 | 1 57 16.03 | 11 59 32·5 | 1 23·22 | 1 58 39·25 |
| Mon. 25 | 115 | 2 8 30·76 | 12 59 29·4 | 1 58·16 | 2 10 28·92 |
| Thur. 28 | 118 | 2 19 49 81 | 13 57 31·5 | 2 28·78 | 2 22 18·58 |
| Sun. M. 1 | 121 | 2 31 13·51 | N. 14 53 30·4 | 2 54·74 | 2 34 8·25 |

75th Meridian Time, Hours numbering from Midnight

### Planetary Phenomena

| | | | Minima of Algol | Configuration of Jupiter's Satellites at 23h 30m |
|---|---|---|---|---|
| | | | h m | |
| Fri. | 1 | | 15 27 | 21○43 |
| ☾ Sat. | 2 | 19h 47 6m Last Quarter. | | 14○23 |
| Sun. | 3 | 17h 59m ☌ ♃ ☾, ♃ 3° 49′ N. | | 42○31 |
| Mon. | 4 | | 12 16 | 4321○ |
| Tues. | 5 | 18h ☌ ☿ ☉ Superior. | | 43○21 |
| Wed. | 6 | 5h 51m ☌ ♀ ☾. ♀ 7° 42′ N. | | 431○2 |
| Thur. | 7 | 1h □ ♅ ♓. | 9 05 | 42○13 |
| Fri. | 8 | | | 412○3 |
| ♈ Sat. | 9 | 16h 25·1m New Moon; 22h 19m ☌ ☿ ☾, ☿ 2° 59′ N. | | 24○23 |
| Sun. | 10 | 1h 51m ☌ ♄ ☾, ♄ 0° 40′ N.; 3·7h ☾ in Perigee. | 5 54 | 24○13 |
| Mon. | 11 | 1h ☌ ☿ ♄, ☿ 2° 21′ N.; 9h ☿ in ♌. | | 231○4 |
| Tues. | 12 | | | 3○214 |
| Wed. | 13 | 16h 41m ☌ ♂ ☾, ♂ 0° 28′ S. | 2 43 | 31○24 |
| Thur. | 14 | [in Perihelion. | | 2○314 |
| Fri. | 15 | 15h 43m ☌ ♆ ☾, ♆ 4° 33′ S.; 19h □ ♃ ♑; 23h ☿ | 23 32 | 21○34 |
| ☽ Sat. | 16 | 9h 4·0m First Quarter; 22h ☌ ♄ ♑. | | ○1234 |
| Sun. | 17 | | | ○234● |
| Mon. | 18 | | 20 21 | 231○4 |
| Tues. | 19 | | | 34○21 |
| Wed. | 20 | | | 413○2 |
| Thur. | 21 | | 17 10 | 42○1● |
| Fri. | 22 | 0h 30m ☌ 24 ☾, 24 2° 48′ S. | | 421○3 |
| Sat. | 23 | 10h ♀ Greatest elongation W. 46° 13; 11h ☿ in ♌. | | 4○123 |
| ♉ Sun. | 24 | 8h 22·7m Full Moon; 9·2h ☾ in Apogee. | 13 59 | 4○23● |
| Mon. | 25 | | | 4231○ |
| Tues. | 26 | 6h ☿ Greatest Heliocentric Lat. N. | | 34○1● |
| Wed. | 27 | | 10 48 | 31○42 |
| Thur. | 28 | | | 23○14 |
| Fri. | 29 | | | 21○34 |
| Sat. | 30 | 8h ♃ Stationary. | 7 37 | ○1234 |

For Jupiter's Satellites, the circle ○ represents the disc of the planet; 24 signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc or in the shadow. Configurations are for an inverting telescope.

## Radiant Points of Meteor Showers

| Date | R. A. h | m | Dec. ° | |
|---|---|---|---|---|
| March 1 | 3 | 10 | 45 | Near $\kappa$ Persei |
| March 4 | 11 | 44 | 9 | |
| Mar. 11–May 31 | 17 | 32 | 50 | The Draconids; near $\beta$ Draconis |
| March 14 | 11 | 40 | 10 | Near $\gamma$ Virginis |
| March 24 | 10 | 44 | 58 | Near $\beta$ Ursæ Majoris |
| March 27 | 15 | 16 | 32 | Near $\eta$ Coronæ Borealis |
| March 28 | 17 | 32 | 62 | Near 26 Draconis |
| Apr. 5–May 10 | 18 | 08 | 35 | The Lyrids; near $\kappa$ Lyræ |
| Apr. 9-12 | 16 | 36 | 51 | Near 42 Herculis |
| Apr. 12–June 30 | 15 | 40 | 23 | The Coronids; near $\alpha$ Coronæ Borealis |
| Apr. 18 | 15 | 24 | 17 | Near $\beta$ Serpentis |
| Apr. 19 | 15 | 16 | -2 | Near $\mu$ Serpentis |
| Apr. 20 | 17 | 57 | 32 | Comet I, 1861; near $\xi$ Herculis |
| Apr. 29–May 2 | 21 | 44 | -2 | The Aquarids: near $\mu$ Aquarii |

## Occultations of Stars by the Moon*

| Date | Star | Mag. | Time | | | | Position Angle | |
|---|---|---|---|---|---|---|---|---|
| | | | Immersion | | Emersion | | Immersion | Emersion |
| 1910 | | | h | m | h | m | ° | ° |
| Mar. 1 | 26 *Libræ* | 6·3 | 15 | 8·2 | 16 | 26·2 | 142 | 279 |
| " 16 | $\tau$ *Tauri* | 4·5 | 7 | 35·8 | 8 | 38·8 | 51 | 287 |
| " 31 | 136 *G Ophiuchi* | 6·3 | 13 | 17·5 | 14 | 31·0 | 120 | 278 |
| " 31 | 151 *G Ophiuchi* | 6·0 | 16 | 13·9 | 17 | 35·9 | 121 | 262 |
| April 12 | 51 *Tauri* | 5.6 | 6 | 37·2 | 7 | 39·7 | 88 | 248 |
| " 12 | 56 *Tauri* | 5·2 | 7 | 14·9 | 8 | 12·4 | 62 | 279 |
| " 13 | *Mars* | | 4 | 25·2 | 5 | 37·2 | 107 | 231 |
| " 16 | $\lambda$ *Cancri* | 5·9 | 4 | 48·3 | 6 | 4·8 | 81 | 301 |
| " 18 | $\eta$ *Leonis* | 3·6 | 5 | 30·4 | 6 | 51·4 | 119 | 288 |
| 25 | 11 *H Libræ* | 5·4 | 14 | 14·7 | 15 | 39·7 | 120 | 288 |
| " 26 | $\rho$ *Ophiuchi* | 4·7 | 16 | 50·0 | 18 | 3·1 | 118 | 263 |
| " 30 | *A Sagittarii* | 4·9 | 13 | 59·3 | 14 | 58·8 | 126 | 220 |

*Computed by R. M. Motherwell for the Dominion Observatory, Ottawa.